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# THE NEW WATER SUPPLY OF THE CITY OF PROVIDENCE.

BY FRANK E. WINSOR.*

*Present Supply and New Supply Compared.* The present supply is taken from the Pawtuxet River at Pettaconset with a drainage area of 199.6 sq. mi. where the water is first pumped from the river to filter beds, is filtered and again pumped to a distributing reservoir about 170 ft. above the filters, from which is supplied the low service area of the city.

For some years the quantity used has been considerably greater than the natural low flow of the river and the supply has been maintained by water stored by the mills located above the intake and let down by them for their own use.

The water at the present source is polluted by trade wastes and human dejecta, most of which enters the river from mills and mill villages having an aggregate population of over 30 000 people and located within a radius of about 8 mi. of the pumping station.

The new supply will be taken from about 92.8 sq. mi. of drainage area which is a part of the area tributary to the present supply but which is above practically all sources of pollution. It involves the building of a large storage reservoir on the north branch of the river from which water will be conveyed by gravity to an elevation about 50 ft. higher than the present distributing reservoirs which serve the low service area of the city. The drainage area of the new reservoir, while slightly less than half that tributary to the present pumping station, will be sufficient with available storage to guarantee a safe yield to the city of 85 m.g.d. or nearly four times the present consumption and fully seven times the natural low water flow at Pettaconset.

*Details of Present Supply.* Agitation for a comprehensive water supply for the City of Providence began about 75 years ago. In March, 1853, the City Council created a committee of investigation and between this date and 1868 five different committees made six separate reports. The water supply project was three times defeated by votes of the tax payers, who, however, finally approved the plan which provided the present supply,

*Chief Engineer Providence Water Supply Board.

the first service pipe of which was opened on December 1, 1871. The present supply is under the able direction of City Engineer, Milton H. Bronsdon, member of this Association.

Water is taken from the Pawtuxet River at Pettaconset, about 3½ mi. from tide water and at about elevation 10.* Since 1905, when filtration was introduced, water has been first pumped from the river by low lift pumps to the filters from which it flows to an open pump well and is again pumped to Sockanosset Reservoir about a mile distant at an elevation of 181.75.

Sockanosset Reservoir is about 5½ mi. from the center of the city and from it is supplied by gravity most of the area of the water district below elevation 90. The water from this reservoir also flows into Hope Reservoir located near the center of the city at elevation 162.5, which latter reservoir serves to equalize fluctuations of consumption and provides a considerable storage near the center of population. There is another pumping station at Hope Reservoir which raises water to the high service storage reservoir at Fruit Hill at elevation 274.75, from which those parts of the city above about elevation 90 are supplied, and which also furnishes high pressure to a special fire district covering generally the congested business area of the city. About 15 per cent. of the present consumption is used in the high service area. The filter plant, prior to the completion of which, in 1905, water was used direct from the river, consists of 10 acres of slow sand beds, originally open but after a short period of operation roofed over with concrete groined arches covered with earth. The filters are generally operated at a rate somewhat less than 3 million gallons per acre daily. For the past 5 years the safety of the water has been further assured by chlorination subsequent to filtration.

### Pumping Equipment in General Use.

*At Filter Plant Lift about 9 Feet.* 2 DeLaval horizontal centrifugal pumps direct connected to Bullock 500-volt D.C. 50 h.p. motors, current for which is either generated by steam at the Pettaconset Pumping Station or is purchased from the Narragansett Electric Lighting Co. Capacity of each unit 20 m.g.d.

*At Pettaconset Station Lift about 172 Feet.* 1 Allis-Chalmers vertical triple expansion engine and pump, capacity 25 m.g.d. 1 DeLaval horizontal centrifugal pump direct connected to a General Electric 2 200-volt A.C. 1 300 h.p. motor, current purchased from the Narragansett Electric Lighting Co., capacity 30 m.g.d. There are three other pumps located at Pettaconset, some of which are obsolescent, which have a combined rated capacity of about 29 m.g.d.

All of the above pumping plant will be abandoned following the introduction of the new supply.

*Elevations are above mean high water of Providence harbor.

*At Hope Reservoir Lift about 112 Feet.* (High Service.) 1 Worthington horizontal triple expansion engine and pump, capacity 10 m.g.d.

1 DeLaval steam turbine driven centrifugal pump, capacity 8 m.g.d.

About one half the present high service area may be supplied by gravity from the new system and the future lift will be greatly reduced.

| Reservoirs. | Elevation (full). | Area Acres. | Capacity Million Gal. |
|---|---|---|---|
| Sockanosset | 181.75 | 11.0 | 55.0 |
| Hope | 162.50 | 12.5 | 76.0 |
| Fruit Hill | 274.75 | 4.5 | 25.0 |

It is probable, owing to the future higher level of gravity distribution that Sockanosset and Hope Reservoirs will be eventually superseded by a new covered reservoir on Neutaconkanut Hill at the west side of the city at an elevation of about 225. Fruit Hill reservoir will also probably be eventually superseded by a new covered high service reservoir about ½ mi. northerly from it at an elevation of about 305. Land for both of these new reservoirs has already been acquired by the city. Inasmuch as the new supply will eliminate all pumping, except to a much reduced high service area, thus reducing the hazard of interruption of service, the tentative designs of the new covered distribution reservoir contemplates much less storage capacity than at present, with, however, provisions for enlargement as the consumption increases.

The sizes and lengths of pipe in the present system are as follows (as of December 31, 1921):

| | |
|---|---|
| 42 in. | 25 631 ft. |
| 36 in. | 10 242 ft. |
| 30 in. | 61 592 ft. |
| 24 in. | 50 824 ft. |
| 20 in. | 9 626 ft. |
| 16 in. | 115 659 ft. |
| 12 in. | 184 800 ft. |
| 10 in. | 14 622 ft. |
| 8 in. | 351 816 ft. |
| 6 in. | 1 515 815 ft. |
| | 2 340 627 ft. |

| | |
|---|---|
| Number of public fire hydrants in use December 31, 1921, | 2 702 |
| Number of services in use December 31, 1921 | 34 055 |
| Number of meters in use December 31, 1921 | 32 232 |
| Per cent. of services metered December 31, 1921 | 95 |

The area supplied includes portions of City of Cranston and of the Towns of North Providence, Johnston and Warwick.

Statistics of population, estimated consumption, etc., are shown upon the diagram below, Plate 1.

The population, and per capita consumption calculated therefrom, shown on Plate 1 by full lines, are based from 1915 to 1920 inclusive upon

the assumption that the change in population from the State Census in 1915 to the Federal Census in 1920 was proportional to the time. It is the writer's belief that the Federal Census for 1920 was much too low.

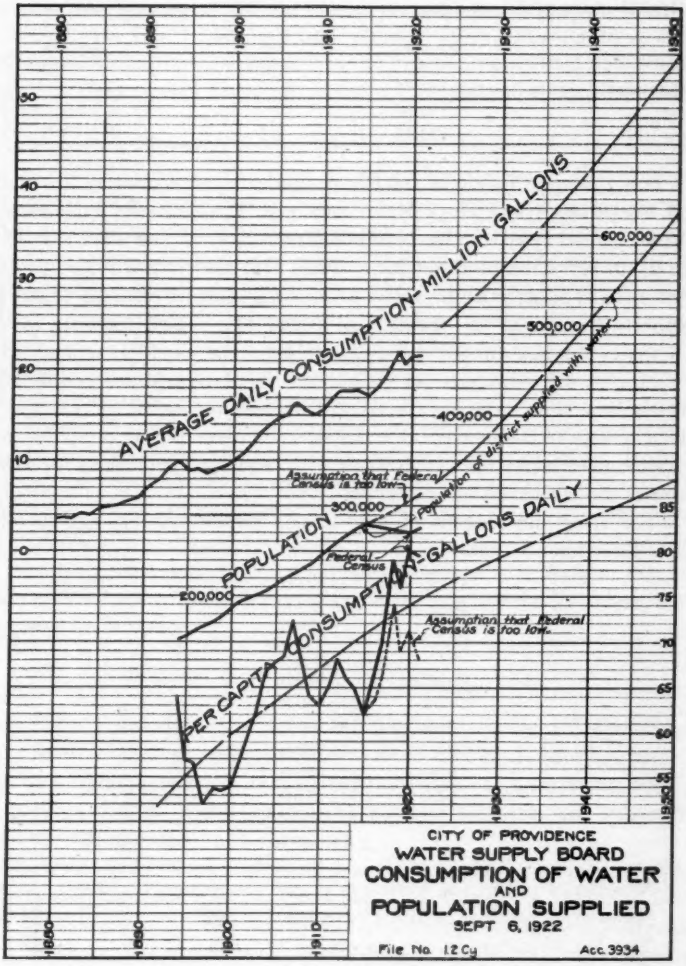



PLATE I.

If the City Engineer's estimate (as published in his Annual Reports) of population of water district from 1916 to 1919 be used, and the writer's estimate of 305 000 for 1920 and 312 000 for 1921 be taken, the population and per capita consumption for each year are shown on this plate by broken

lines. Estimated future population is based upon past growth and the increase which has actually occurred in cities similar to but now larger than Providence. Future per capita consumption is believed to be conservatively estimated and assumes a metered system coupled with the same careful management which has characterized the water works from their beginning.

The average hardness and alkalinity of the river water of the present supply in parts per million was 10.5 and 6.4 respectively for 1921.

In 1921 the average color of the present supply before and after filtration was 45 and 29 respectively. The filters remove nearly uniformly about one-third of the color in the raw water. The filtered water varies in color from about 15 to 50 with occasional higher peaks, for example, in the summer of 1916 it was above 60 for about three weeks and in August, 1922, a maximum of 54 was reached. Even when most highly colored the water is bright and sparkling, the color being a vegetable stain or dye.

The gross revenue of the water works has increased from about $855 000 in 1913 to $986 000 in 1921. The outstanding bonded indebtedness on December 31, 1921, was $1 632 000 old bonds and $1 000 000 for new works. It is expected that with some slight readjustment of water rates, the net income from the water works will be sufficient to defray interest and sinking fund charges on the new water supply, and additions to and changes in the distribution system, all of which are now estimated to cost about $20 000 000.

*Details of New Supply.* Investigations for a new supply were begun by a committee of the City Council in 1913. An Act was presented to the General Assembly of the State at the January session, 1914, but failed to pass, and after some modification the present Act, under which the work is being carried on, was passed at the following session and became a law on April 21, 1915.

Some rather unusual features of the law are as follows:—

(a) As one of the results of the preliminary investigations and discussion the outside boundary within which the City could condemn land for reservoir purposes was prescribed.

(b) The right of condemnation of either land or water rights was limited to two years after passage of Act.

(c) In case a part only of any farm or of any lot or tract of land is taken under any of the provisions of this Act . . . . . and the remainder or any portion thereof . . . . . is damaged or lessened in value by such taking, the owner or owners thereof may surrender to said City the portion so damaged or lessened in value . . . . within one year after said taking; whereupon, the portion so surrendered shall be deemed to be included in such taking . . . . . (applies to taking for reservoir only).

(d) Similar provision for surrender of mill property including reservoirs, dams, etc.

(e) Owners of land contiguous to that taken for reservoir purposes, which is directly or indirectly decreased in value thereby, are permitted

to recover, provided they filed a claim within three years after passage of Act.

(f) Damages to business and damages for loss of employment are provided for.

(g) Very elaborate provisions are made for the regulation of flow in the stream past the dam from the time the city first begins to interfere with the stream; e.g., the city cannot hold or divert any water until the reservoir is ready for use; from the time the city first begins to store water until for the first time 20 000 000 000 gal. have been stored, the city shall not reduce the natural flow of the stream during any week day, except that it may hold any water in excess of 20 m. g. d. flow; after 20 000 000 000 gal. are first stored the city shall draw from the reservoir not less than 70 m.g.d. and the portion of this not used for water supply shall be discharged into the river below the dam, concentrated so as to best meet the requirements of the mills below (the above quantity of 70 000 000 gal. may be temporarily reduced to 65 000 000 gal. provided the reservoir does not fill by June 1 in any year); the city shall forever discharge 500 000 gal. per day from the reservoir and such further amount as may be necessary to maintain a flow of 6 000 000 gal. each day into the Arkwright mill pond (located about 3 mi. downstream from the reservoir with an intermediate drainage area of 9.4 sq. mi.); also under certain conditions such further amount as may be necessary to maintain a flow not exceeding 72 000 000 gal. weekly into the Clyde mill pond (located about 5 mi. downstream from the reservoir with an intermediate drainage area of 13.2 sq. mi.); the city is required to establish and maintain gaging stations at or near Arkwright and Clyde.

The Act at its passage in April, 1915, established an unpaid Water Supply Board consisting of the seven persons who then constituted the committee on increased water supply previously appointed by the City Council. The personnel of the Board has remained unchanged and their sustained intelligent interest and unselfish public service has insured a continuity of policy which has been a potent factor in the prosecution of the work. The preliminary investigations prior to 1915 were made under the direction of the late Samuel M. Gray, then a member of this Association, and the general plans then outlined have been followed in the subsequent development of the project. The writer became Chief Engineer in August, 1915, and complete topographic and real estate surveys were pushed to completion as rapidly as possible. Horizontal control was insured by a rectangular coördinate system established by triangulation and vertical control by a net of precise levels. Subsurface investigations for all structures were begun almost immediately. All structures connected with the reservoir, including relocated roads, new cemetery, dam, dike, etc., were located, approval obtained from various authorities as necessary and title taken by condemnation to the entire area of 12 450 acres on December 6, 1916. Similarly title was taken to land required for the aqueduct on April 4, 1917.

The first construction contract, for river control at the Main Dam, was let in January, 1917, and it was then expected to follow this with a contract for the major part of the work on the dam in the fall of that year.

Owing to the coming on of war in April, 1917, the major contract referred to was not let until May, 1921, and the completion of the entire work has been of necessity delayed thereby from two to three years. It is now expected to begin storage of water in the summer or fall of 1925 and, dependent upon rainfall and run-off, to begin furnishing water either in the summer of 1926 or the following winter. The essential construction program should be completed in 1926 if present plans are carried out.

Following is a summary of statistics of the new supply:

SCITUATE RESERVOIR

| | |
|---|---|
| Drainage area | 92.8 sq. mi. |
| Storage capacity | 36 900 000 000 gal. |
| Area of water surface | 3 600 acres. |
| Average depth of water | 32 ft. |
| Flow line elevation above mean high water of Providence harbor | 284 ft. |
| Maximum depth of water (in river bed at dam) | 87 ft. |
| Length of east branch, measured from dam, about | 7 mi. |
| Length of west branch, measured from dam, about | 5.7 mi. |
| Maximum width, near dam, about | 2¼ mi. |
| Length of flow line, not including islands, about | 38 mi. |
| Number of islands | 28 |
| Highways to be abandoned (including 7.4 mi. regraded) | 34.7 mi. |
| Highways to be built and regraded | 26.0 mi. |

*Real Estate.*

| | |
|---|---|
| Area which City was permitted by law to acquire | 16 000 acres |
| Area which City condemned for reservoir | 12 450 acres |
| Length of main taking line | 56 mi. |
| Total area which City condemned for reservoir, new highways and cemeteries | 12 547 acres or 19.6 sq. mi. |
| Total area, including property surrendered, which City will control, about | 15 000 acres |
| (Total area of the City of Providence is 11 700 acres) | |
| Dwelling houses on condemned area | 357 |
| School houses on condemned area | 7 |
| Churches on condemned area | 6 |
| Cotton mill plants on condemned area | 6 |
| Total buildings on condemned area | 1 195 |
| Cemetery lots on condemned area | 173 |

*Main Dam.*

| | |
|---|---|
| Length, about | 3 200 ft. |
| Maximum height above valley, about | 100 ft. |
| Maximum height above bed rock, about | 180 ft. |
| Maximum thickness at base | 640 ft. |
| Thickness at flow line | 118 ft. |
| Width on top, 13 ft. above flow line | 37 ft. |
| Cubic contents of dam, including refilling below surface of the ground, about | 2 500 000 cu. yds. |
| Length of spillway at west end of dam, (net) about | 413 ft. |
| Length of spillway channel to river below dam, about | 1 800 ft. |

*Dike.*

| | |
|---|---|
| Length, about | 4 000 ft. |
| Maximum height above the surface of the ground, about | 33 ft. |
| Average height above surface of the ground, about | 15 ft. |

*Aqueduct.*

| | |
|---|---|
| Total length from gate house in dam to present distribution system, about | 7 mi. |
| Land condemned, about | 80 acres |
| Minimum width of taking | 50 ft. |
| Maximum width of taking (except at shaft and tunnel portals) | 200 ft. |
| Tunnel, concrete lined, equivalent to about 7 ft. 9 in. diameter circle | 3½ mi. |
| Depth of construction shaft, about 7 200 ft. from east portal | 140 ft. |
| Masonry aqueduct or pipe lines in open cut | |
| West of tunnel | 1 mi. |
| East of tunnel | 2¾ mi. |

*Scituate Reservoir.* After a thorough investigation it was decided in 1916 not to strip the top soil from the area to be flooded as was done at the Wachusett Reservoir of the Metropolitan System, as the benefits therefrom would, it was believed, be incommensurate with the cost. It is the writer's opinion that, while removal of soil may be and in some instances undoubtedly has been very beneficial in the early years of a reservoir's use, it probably accomplishes little or nothing of permanent value and that it cannot be considered in any sense a satisfactory substitute for filtration. With present and prospective wage scales and the proportion of hand labor involved, it seems reasonably certain that soil removal from large storage reservoirs will seldom if ever be economically justified in the future. The reservoir area including a 30-foot marginal strip will be cleared of all vegetation immediately prior to flooding and stumps and roots will be generally removed from areas to be submerged less than about 25 ft. It was also decided in 1916 to filter the new supply.

The principal shallow flowage area is at the upper end of the east arm of the reservoir and to insure keeping this area flooded when the main reservoir is drawn down, and to provide, before the completion of the new project, some storage which could be sent down the river, if and as needed, to the present Pettaconset Pumping Station, a structure known as the Regulating Dam was designed and built in 1918 at the village of North Scituate. The dam floods an area of about 210 acres to a maximum depth of about 12 ft., with an average depth of about 5 ft. at Elevation 284, the level of Scituate Reservoir. In order to increase the capacity temporarily the reservoir has been maintained generally at Elevation 285.5 by 18-in. flashboards, thus providing a storage of about 420 000 000 gal. which has been available if and as needed at Pettaconset since the spring of 1919. This dam as shown on the accompanying photograph is circular in plan and of a true arch type. The radius of the upstream edge of the dam is 50 ft. and the ends near the highway connect with the abutments of the

REGULATING DAM AT NORTH SCITUATE.
With 7 inches depth of water over flashboards, September 12, 1919.
(Since the photograph was taken the ends of the dam have been extended to the nearer cross walls and additional walls added to connect with the wing walls of a new bridge just downstream.)

new Danielson Pike Bridge by reverse curves. The spillway has a net length of about 220 ft., the concrete crest being at the same elevation as the crest of the spillway of the Scituate Reservoir about 6 mi. below. The dam is mainly on coarse sand and gravel and water-tightness was secured by placing a blanket of soil and subsoil 2 ft. thick, rolled in thin layers, outside the wall of the dam for a radial distance of 75 ft. The concrete section except at the abutments and gate chamber, is L shaped being 15 ft. high and vertical on the water face and 10 ft. wide on the bottom. The thickness of the wall at the spillway level is 30 in., and 12 ft. down, 42 in., this being the level of the concrete apron which forms the horizontal part of the L and which is 3 ft. thick. The water falls over the spillway and drops 12 ft. on to the concrete apron, which is 6 ft. 6 in. in width. The bottom is further protected by paving 6 ft. in width and additional protection is provided in front of the gate chamber through which the water is drawn off.

*Scituate Aqueduct.* The Scituate Aqueduct runs in an easterly direction from the Main Dam to the present distribution system near Sockanosset Reservoir and is about 7 mi. long, $3\frac{1}{3}$ mi. of which is in tunnel, a contract for which was awarded September 6, 1922. The westerly end of the aqueduct at the Scituate Dam is only about 10 mi. from the civic center of Providence and when the great distances that many cities have had to go for water are considered, it is remarkable that a sparsely settled drainage area of 92.8 sq. mi., all situated in the small state of Rhode Island, is available so near at hand.

*Subsurface Investigations.* Subsurface investigations were begun late in 1915. These investigations may be divided into 4 classes:

1. Wash borings to the surface of the rock, followed by diamond drill borings into rock.
2. Wash borings to determine character of material except rock.
3. Rod soundings to eliminate rock to the depth of the sounding.
4. Test pits.

(1) Work under class 1 was done entirely by contract with Sprague & Henwood, Inc., of Scranton, Pa. The material overlying the rock contains commonly boulders of both large and small size and core borings only were depended upon for accurate information as to the locations of ledge rock. In connection with the investigations for the dam, tunnel and other works, a total of 202 borings was made in this class aggregating 5 202 ft. of wash boring and 3 738 ft. of core boring in rock. The total cost of the work, exclusive of administration and engineering, was $18 416, making the average price paid per foot for wash and core borings respectively, $1.65 and $2.63. Great care was taken in the preservation of cores in rock and to obtain accurate information in regard to the character of the overlying material. Some of the provisions of the specifications are as follows:

An accurate record shall be kept of all materials penetrated as well as the depth of each boring. Samples of the materials penetrated, other than cores of rock, shall be taken in the manner, and as frequently as directed, placed in receptacles, furnished by the Board, which shall be so numbered and marked as to be readily identified, and shall be delivered in boxes, furnished by the Contractor at such places as the Engineer may direct. The cores of rock shall be carefully handled so that they will not be destroyed or injured. They shall be carefully preserved, marked and placed in wooden boxes, furnished by the Contractor, of a design approved by the Engineer. Upon the completion of a hole the covers of the boxes shall be securely screwed on and the boxes delivered at such places as directed and shall remain the property of the City. Should it prove impracticable at any depth to obtain a core, or should a seam be encountered, particular care shall be taken to get accurate samples of the materials penetrated and the correct limits between which no core can be obtained.

It is important that as large a percentage as possible of the cores shall be recovered, and the Contractor shall regulate the speed of his drill and remove the core as frequently as directed in order to maintain a maximum percentage of recovery, special care being taken where the character of rock being penetrated is uncertain. If the appliances on any machine are not such as will give a reasonable amount of core in the opinion of the Engineer, the Contractor shall furnish such appliances as will be satisfactory.

Blasting with small charges will be allowed for the removal of a boulder or other obstruction which cannot be conveniently removed otherwise.

The Contractor shall drive to such depths as directed, generally to sound bed-rock, a wrought-iron or steel casing at such points as are designated. These casings shall be of such sizes that it will be feasible to continue the boring into bed-rock, as a core boring.

The casings for the wash borings are to be driven by some suitable form of wash-boring rig that will penetrate all material other than sound rock to be found in the territory to be explored and give the speed required for the completion of the work. The wash water may be used repeatedly if necessary, but sufficient tubs or buckets shall be provided to allow all the coarser material to settle out before using the water again. Where the character of the material will permit, it is desirable to drive not over 5 ft. before each washing, and under no circumstances may the wash pipe advance more than 6 in. below the bottom of the casing.

The Contractor shall provide all facilities and assistance necessary to secure samples of materials penetrated whenever required. Dry samples obtained by forcing the sampler tube below the limits of the washing, will, in general, be required about every 5 ft. in depth and may be required at more frequent intervals.

Whenever ordered, wash borings which have been carried to sound bed-rock shall be further continued by core borings into the sound rock to such depths as may be deemed advisable by the Engineer, usually about 20 ft. Unless otherwise permitted, cores shall have diameters of not less than $1\frac{1}{8}$ inches if diamond drills are used and not less than $2\frac{1}{2}$ inches if shot drills are used.

While the specifications permitted using shot drills, the contractor actually used only diamond drills. The method used in obtaining samples was also used in all wash borings done under (2) and was found to be extremely satisfactory, the materials indicated by the samples being thus far in very close agreement with those found where actual excavations have been made.

In addition to the diamond drill borings made by the Board, 27 borings having an aggregate depth of 790 ft. in earth and 358 ft. in rock were made by the Committee of the City Council, mainly in 1914.

(2) Extensive investigations were made by wash borings to determine the character of material available for building the dam, and to obtain negative information as to rock at various other structures. The method of taking samples was the same as already described and no samples were permitted to be taken of material washed out of the various holes, unless it was found impossible to get dry samples. One hundred twenty-two borings having an aggregate depth of 3 046 ft. were made.

(3) Rod soundings made by driving a rod into the ground were also made by employees of the Board, the aggregate depth for 1 264 soundings being 6 649 ft.

(4) 1 143 test pits were made for a variety of purposes, some 725 of them (total depth 1 750 ft.) being to determine the material available for impervious core, which investigation covered a very large area below the flow line of the reservoir.

Nearly all of this work was done by labor directly employed by the Board.

*Rainfall and Run-off.* A record of the rainfall and run-off on the North Branch of the Pawtuxet River has been kept since 1916, indicating conditions in general similar to those of the Wachusett Reservoir for the same period. The average yearly rainfall for the past six calendar years was 48.8 in., with an average run-off, from land surfaces only, of 57.5 per cent. the corresponding figures for the Wachusett drainage area being 45.1 in. rainfall and 57.8 per cent. run-off from land surfaces only. The estimated average long term rainfall on the Scituate Reservoir drainage area is about 45.5 in. as compared with the Wachusett average from 1897 to 1921 inclusive, of 45.3 in. The average elevation of the drainage area of Scituate and Wachusett Reservoirs are 470 and 750 ft. above sea level respectively. Detailed figures of rainfall and run-off are given in the annual reports of the Water Supply Board and also in *Water Supply Papers 501 and 521* of the U.S. Geological Survey.

Four standard 8 in. Friez rain gages are maintained and a Gurley automatic elevation-recording stream gage makes a continuous record of the depth of water on the Fiskeville dam, an unused mill dam about 3½ mi. downstream from the Scituate Dam, the watershed area of which is 101.8 sq. mi. The discharge curve for the Fiskeville dam was based on experiments at Brown University in 1916 on a model section checked by current meter observations at a convenient point a short distance upstream and further checked by published experimental data in *Water Supply Paper No. 200* of the U. S. Geological Survey and elsewhere. There have been no floods of magnitude since the gaging station was established, but it is of interest to note that the two highest run-offs occurred in July and September of this year, the peaks at Fiskeville being 26 and 28 second feet per

square mile of total drainage area. At the time of the July storm a peak of 50 second feet per square mile was reached from 22 sq. mi. of this same drainage area at the regulating dam at North Scituate. The summer rainfall and run-off of 1922 has probably seldom if ever been exceeded in this locality.

*Quality of Water in Scituate Reservoir.* The average hardness and alkalinity of the water flowing past the site of the Main Dam during 1921 was about 6.3 and 4.0 parts per million respectively. The color of the present stream at the Main Dam, based mainly upon observations during the past 6 years, averaged 46 with considerable variations. On 48 sampling days in 1916 the average color was 43, 36 of these days being between 26 and 50 and 12 days between 51 and 100. On 31 sampling days in 1917 the average color was 39, 28 of these days being between 26 and 51, and 3 days between 51 and 100. In the early years after filling it is probable that there will be little if any improvement in color over the average of the influent water and in fact temporary seasonal increases in color may be expected. It seems certain, however, that after a few years the reservoir with its storage of 400 000 000 gal. per sq. mi. (the Wachusett Reservoir stores about 600 000 000 gal. per sq. mi.) will have a strong decolorizing or bleaching effect upon the water stored. The average population on the drainage area will in 1925 probably not exceed 25 persons per sq. mi., mostly being on isolated farms with, however, some local concentrations, the largest of which will be in North Scituate about six miles above the reservoir intake at the dam. The city owns more than 20 per cent. of the drainage area, the taking line except at North Scituate being generally at least 500 ft. distant from the flow line and averaging over one quarter mile. The type of filters, which will be located between the dam and the tunnel, has not yet been determined. It has not yet been necessary to design the filters, as their construction need not be begun before late in 1923, and in the meantime advantage may be taken of any advances in the art of treating water of this character.

*Cemeteries.* Upon the area acquired by the city there were 101 farm cemeteries and a community cemetery near Rockland containing about 75 lots. The total number of known bodies was 2 308 which number has been materially increased by the discovery of unmarked graves as the work of removal progressed. About one half of the farm cemeteries are so far distant from the flow line that their removal is unnecessary, although further burials have been prohibited. A new cemetery known as the New Rockland Cemetery was established upon a sandy knoll about $\frac{5}{8}$ mile distant from the flow line of the Rockland arm of the reservoir and 6 miles distant from the dam. The removal of bodies was begun in September, 1918, and this work was practically finished in July, 1922. The development of the cemetery, including drives, etc., was done by forces in the direct employ of the Board, as was also nearly all the work of removal of bodies thereto, moving and resetting headstones, monuments, etc. The new

cemetery was laid out and the plan filed in the records of the town where located. In consideration of a release to all right, title and interest in the old ground, parties interested are given a deed to a lot sufficient for their needs in the new grounds, and the bodies in which they are interested, together with head stones and monuments, moved thereto. Some of the rules of the new cemetery are as follows:

All work in the old and new cemeteries shall be done only by parties previously approved by the city.

All lots shall be bounded by permanent concrete monuments provided by and set by the city, such monuments to be 5 in. square and 20 in. long.

There shall be no curb stones, iron or stone fences or close hedges permitted.

No foot stones will be permitted and foot stones in existing grounds will not be brought to the new grounds.

Head stones shall be set at least as permanently and satisfactorily as in present grounds.

Field stones without lettered inscriptions marking graves in existing grounds will not be moved to the new grounds.

Suitable records shall be kept showing the position of all unmarked graves in the new cemetery and the locations from which they were removed.

The work of removing cemeteries is practically complete, there having been 1 598 bodies removed, of which 1 448 have been moved to the new cemetery, the remainder having been moved to lots provided by parties interested, in other cemeteries, generally in the State of Rhode Island. The grounds have been maintained to date by the city and the approximate cost of the work, including bodies moved to other cemeteries, has been as follows:

Maintenance $2 800, received for original interments, $500, net cost of maintenance $2 300. Development of new grounds $15 800, moving bodies, head stones, monuments, etc., $17 100. Total $35 200. Cost of land $1 700. Total cost including land $36 900. Cost per body moved from old grounds $23.09. The above costs do not include administration, engineering, or fencing, which may later be necessary.

## Main Dam and Dike.

The accompanying plans, Plates II and III, show the main features in the design of these structures.

The cross sections of the valley, the character and depth of the material overlying the rock and the ease and economy of construction of an independent masonry spillway founded on rock clearly indicated an earth dam to be the best and most economical type for the Main Dam. Subsurface investigations of the material overlying the bed rock showed it to be a modified glacial drift varying from very fine sand to coarse gravel with very irregular stratification and freely water bearing. The materials

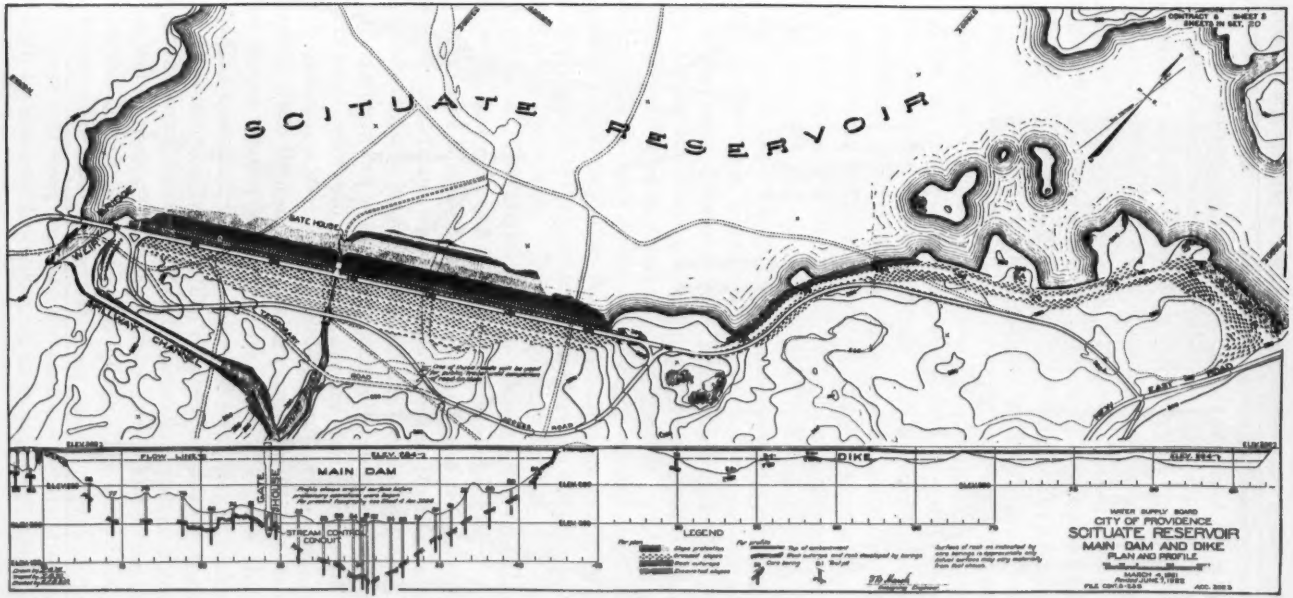

SCITUATE RESERVOIR
GATE HOUSE
WEIR
FLOW WIRES
MAIN DAM
STREAM CONTROL CONDUIT
DIKE
EAST ROAD
LEGEND
WATER SUPPLY BOARD
CITY OF PROVIDENCE
SCITUATE RESERVOIR
MAIN DAM AND DIKE
PLAN AND PROFILE

PLATE II.

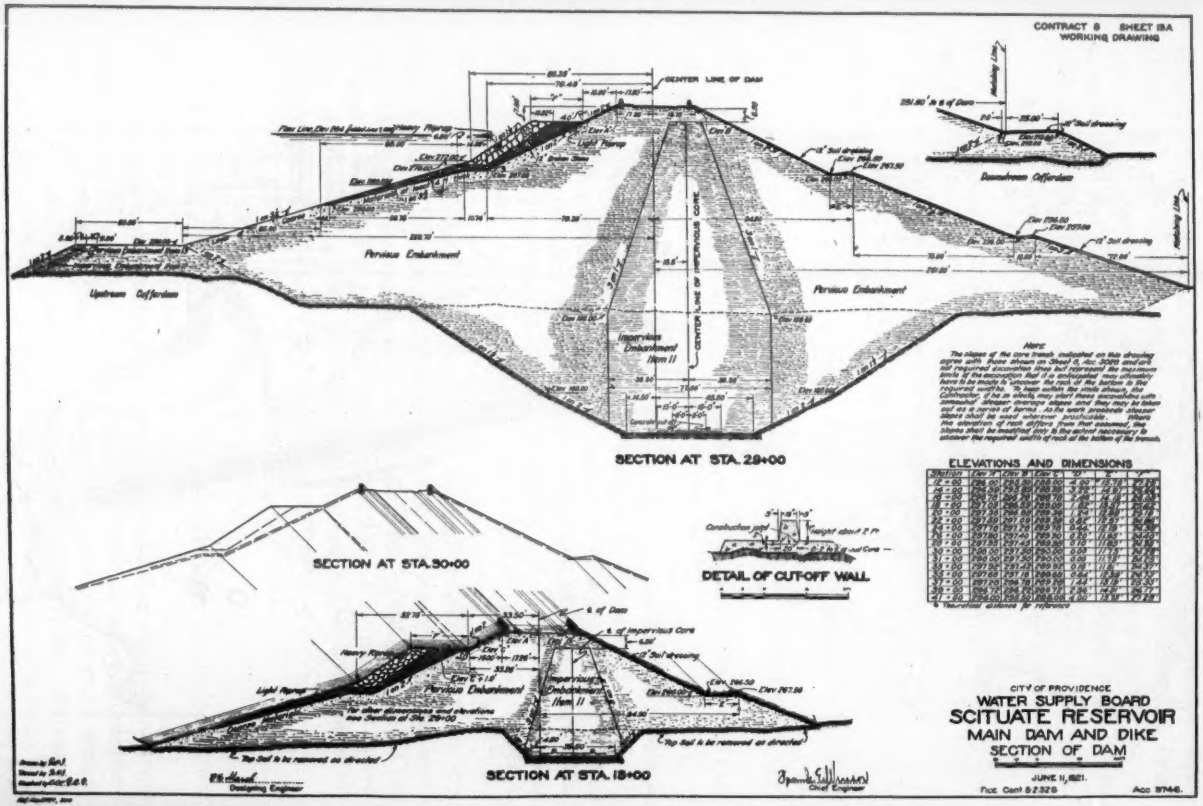

CONTRACT 8 SHEET 19A
WORKING DRAWING
CENTER LINE OF DAM
Pervious Embankment
Upstream Cofferdam
Impervious Embankment Item 11
CENTER LINE OF IMPERVIOUS CORE
Pervious Embankment
Downstream Cofferdam
SECTION AT STA. 29+00
SECTION AT STA. 30+00
DETAIL OF CUT-OFF WALL.
SECTION AT STA. 13+00
ELEVATIONS AND DIMENSIONS
CITY OF PROVIDENCE
WATER SUPPLY BOARD
SCITUATE RESERVOIR
MAIN DAM AND DIKE
SECTION OF DAM
JUNE 11, 1921.
Designing Engineer
Chief Engineer

PLATE III.

encountered in the excavations so far made agree very closely with those indicated by the borings. The underlying rock is a granitic gneiss of fairly uniform quality and no fault appeared in the bottom of the rock valley.

The control of the stream during construction was accomplished by diverting it into a horseshoe shaped conduit 25 ft. wide by 21 ft. 4 in. high and 462 ft. long passing through and under the dam, with its bottom elevations substantially the same as the old river bed. This conduit is founded upon ledge rock and is connected with the river by approach and discharge channels about 1 000 ft. and 200 ft. long respectively. The approach channel is lined with concrete up to the height of ordinary river flows, mainly with the idea that the percolation into the deep portions of the core trench during construction might be reduced thereby. The upstream and downstream sides of the deep excavations are guarded by earth embankments forming the toes of the dam and referred to as the upstream and downstream cofferdams. The upstream cofferdam is at a sufficient height to provide without being overtopped, for the continuous passage of about 150 second feet per square mile through the stream control conduit.

Provision for a flood of this unusual magnitude was considered necessary because of the important mill properties on the stream below the dam which might suffer great damage if accumulated storage was suddenly released by the failure of an inadequate temporary structure. It was also very important to avoid any possibility of flooding the deep portion of the cut-off trench during its excavation and refilling. The largest run-off per square mile in this vicinity, of which any reliable record has been found, occurred in February, 1886, from about 32 sq. mi. of this same drainage area, when a peak of undoubtedly short duration of about 140 second feet per square mile occurred. The storage below the top of the upstream cofferdam is about 2 500 000 000 gal., the accumulation of which would materially reduce the peak of a short quick flood at the dam.

The gate house is located about 60 ft. upstream from the center of dam and over the stream control conduit. When the embankment of the dam is substantially completed a steel and wooden bulkhead will be built at the upstream end of the stream control conduit and a temporary cofferdam near its lower end. The ordinary dry season flow of the stream will then be carried in a 36-in. steel pipe already laid in the masonry invert of the conduit, while the conduit is being plugged at the gate house and permanent stream control gates, etc., are provided. After the closure of the conduit is completed the 36-in. pipe will be permanently closed and the filling of the reservoir begun. The river control conduit downstream from the gate house will be divided by a horizontal floor about half way up, upon which will be supported the pipes which carry water to the City and below which will flow the water released for use of the mills downstream. The gate house will be equipped with shutters which will provide for drawing either city or mill water substantially from the bottom, from a depth of about 47 ft. or from any depth down to 32 ft. below full reservoir level.

The gate house is also designed to permit the installation of turbines capable of developing the power available from either city or mill water passing through the dam. A Venturi meter for measuring the flow of mill water will be provided near the downstream end of the conduit.

The approach to the spillway of the reservoir is separated from the main dam near its west end by a knoll of ledge rock extending slightly above the top of the dam. A three span reinforced concrete arch bridge about 250 ft. long extends over this arm of the reservoir near the spillway and connects the public road to be built over the dam with the main land. The spillway is a solid masonry structure with a maximum height above rock as indicated by the borings of about 20 ft. and with a gross length of about 440 ft. The net length is about 413 ft. and a platform will be provided about 4 ft. above the crest from which low flashboards can be placed to prevent the loss of water due to wave action when the reservoir is full. The length of spillway is conservatively designed in connection with the great area of the reservoir to take care of any possible floods without unduly raising the water surface. The minimum elevation of the top of the main dam and dike is 13 ft. above flow line of the reservoir and the higher portions of the structure will be built with an allowance for ultimate settlement to this minimum. After falling over the spillway the waste water will be conducted back to the river through an excavated channel about 1 800 ft. long, with the bottom, except near the river, in rock.

It was necessary in order to make a tight dam to provide an impervious cut-off down to rock. A thorough examination indicated that soil and subsoil were the only materials available in sufficient quantity and of dependable uniformity for making a water tight cut-off. The material underlying the subsoil within a practicable distance of the dam is modified glacial drift, very similar in its general characteristics to that encountered in the excavation of the cut-off trench. Its very variable character and the absence from large portions of it of fine materials precluded its use for the core.

A masonry core wall was considered and estimates of cost were made with various designs. It was not deemed good design, on account of the very porous character of the material available for the abutting fill, to depend for watertightness solely upon a non-stable masonry wall, of any dimensions economically practicable, which would be apt to crack under unbalanced pressure, and all designs for masonry cores contemplated a considerable amount of soil and subsoil on one or both sides of the wall. The placing of the soil would be complicated by the presence of the wall and it was concluded that a more satisfactory and more nearly watertight structure could be obtained under the conditions which here prevail by the adopted design, which contains about 2½ times more impervious material than the minimum considered with the masonry wall and has also the advantage of considerable economy over any design of masonry core considered.

The possibilities of hydraulic dam construction were considered at great length, and it was finally decided to require that the impervious core be placed in thin layers (not more than 6 in. after rolling) wet and rolled with heavy rollers. There were several reasons for this conclusion, some of which are as follows:

(1) The excavation and refilling of the deep portions of the core trench with a maximum depth of 80 ft. and a length of over 1 000 ft. had to be done generally below the ground water level and the placing of watertight material under these conditions (such material aggregating about one-fourth the entire amount of this material required in the dam) could, it was believed, be only satisfactorily accomplished by a dry method.

(2) The borrow pits available are so varied in character and contain so many large masses of very coarse material that it was considered unsafe, for the portion of the dam above the ground water level, to depend upon them to produce sufficient fine material to secure a satisfactory watertight core, if deposited by the usual hydraulic method of dam construction.

(3) The soil and subsoil which are being used in the core could, it was believed, even in the upper part of the dam, be as economically placed n position by the dry, as by hydraulic methods, particularly when it is considered that a plant for placing about ¼ of it in the dry would be required for the portion of the dam below ground water level.

(4) All the borrow pit material practically available lies in the valley upstream from the dam and to place it in the dam hydraulically would involve lifting to a maximum height of about 90 ft. The material contains considerable amounts of coarse gravel, cobbles and large boulders which would render pumping very difficult and expensive.

The contractor was given an option in the manner of placing the material outside the soil core and he has decided to place substantially all such material with cars, either deposited in two-foot layers consolidated by heavy hose streams or under some conditions dumped into pools of water.

Some clauses in the specifications for the dam affecting the placing of materials are as follows:

SECT. 11.5. *Impervious Embankment of Soil, Item 11.* Under Item 11 the Contractor shall furnish and place the impervious embankment of soil in the core of the dam and dike and in the upstream face of the cofferdam begun under a previous contract, and elsewhere if directed. Material for this portion of the embankment shall consist of top-soil and subsoil, free from vegetation occurring above the ground surface, containing no masses of roots or individual roots more than 24 in. long or ½ inch in diameter, large stones, porous materials and other undesirable matter. It shall be of acceptably impervious quality. Top-soil containing an excess of organic matter, and silt and muck will not be acceptable. Suitable materials from the excavations may be used in the soil embankment. The remainder shall be obtained from approved locations within the reservoir limits but not closer than 500 ft. to the upstream toe of the dam and dike. Such additional material shall not be included for payment under any excavation item, but all cost of excavating and hauling it to the dam and placing it in the embankment shall be included in the price stipulated for Item 11, however great the haul required. The most convenient areas immediately upstream from the dam from which acceptable soil can be obtained are indicated on Sheets 9, 10, and 11 of the contract drawings. To obtain sufficient acceptable material from easily excavated areas it will be necessary to go beyond the areas shown. Acceptable material for impervious embankment will

generally be found only upon upland areas and many large cleared areas in or near the bottom of the valleys, the most extensive of which are near the main dam, will not be permitted to be used owing to the presence of silt, sand and an excessive amount of organic matter. Material placed under Item 11 shall be rolled in 6-in. layers in the manner specified in Section 11.6. Care should be taken in starting the soil embankment for the core to secure thorough filling of all irregularities in the bottom of the trench and a compact bearing of the soil on the top and edges of the concrete covering of the rockand the cut-off walls, described in Section 17.24, without damaging the masonry. This work will require some hand placing and tamping and shall be done with great thoroughness.

SECT. 11.6. *Rolling.* Refills and embankments of soil placed under Item 11 shall, unless otherwise permitted or required, be deposited in approximately horizontal layers not exceeding 6 in. in thickness when compacted, and unless sufficiently moist as spread shall be wetted in such manner as will secure the uniform moistening of all portions of each layer. The compacted surface shall be acceptably sprinkled immediately before placing each new layer. Each layer shall be rolled by approved rollers having grooved or banded rolls. The heaviest wheels of the roller shall cause a calculated average pressure of at least 30 lb. to the square inch on a bearing surface considered as the width of the roll multiplied by half the arc bounding a segment of the roll, at the bottom of the grooves, having a middle ordinate of one inch. The roller shall pass over every part of each layer that can be traversed by it as many times as may be necessary to thoroughly compact the material. Items 11, and 12 or 13, where contiguous, shall be brought up simultaneously, and the thorough compacting of the soil where it adjoins the pervious materials will be essential to avoid an unsatisfactory softening of the embankment from the use of water in compacting the pervious materials. Portions of the refills or embankments which the rollers cannot reach for any reason, shall be compacted by extra-heavy tampers used energetically, or by other means which will secure a degree of compacting equivalent to that obtained by rolling as specified. At the beginning of each season, the surface of the ground or the enbankment previously placed shall be carefully cleaned and thoroughly rolled before placing any new material, to consolidate any portions that may have been loosened by frost action or otherwise.

SECT. 11.7. *Pervious Filling of Deep Core Trench, Item 12.* The refilling of the deep core trench east of the stream control conduit shall be placed by the method outlined in Section 11, unless an alternative plan be approved. The pervious materials each side of the soil core shall be placed under Item 12 in approximately horizontal layers not over 2 ft. thick, consolidated by the use of jets of water from hose under pressure and by allowing the ground water to rise in the materials. If fine sand is used for this refilling it will probably be necessary to maintain a considerable thickness of material above the ground water level to avoid conditions like quick sand. It is essential that the refilling materials be thoroughly consolidated so as to avoid subsequent settlement, and special care shall be taken to wash earth and sand into all interstices of riprap and other piles of rock fragments on the side slopes of the excavation as the filling progresses.

SECT. 11.8. *Pervious Embankment Above Elevation 195, Item 13.* The pervious refilling and embanking for the dam and dike above Elevation 195 shall, unless an alternative plan be approved, be placed under Item 13 in approximately horizontal layers not over 2 ft. thick and consolidated by the liberal use of jets of water from hose under pressure or by other effective means. The water pressure shall be sufficient to easily move coarse sand. The quantity of water that will be required for this purpose cannot be predicted and may vary materially from time to time, depending on the character of the embankment materials and other conditions. For the purpose of a rough estimate it is assumed that the equivalent of 8 in. depth of water on each 2 ft. layer will be ordinarily sufficient, and much less than this may prove to be satisfactory under certain conditions.

Items 12 and 13 above referred to (Sects. 11.7 and 11.8) are pervious, fill both sides of the soil core, and Section 17.24 (referred to Sect. 11.5) is as follows:

SECT. 17.24. *Concrete in Core Trench.* The middle 30 ft. of the bottom of the core trench, excavated and cleaned as specified in Section 4.8, shall be covered or leveled up with concrete to the extent directed from place to place. This work will generally be done before grouting the bottom. The purpose of this concrete is to fill up the larger irregularities of the bottom, to facilitate the grouting and the placing of the soil core, to seal exposed joints and seams in the rock bottom and to form two low cut-offs near either edge of the 30-ft. strip to break the continuity of the contact between the rock and the soil core. Where the bottom is irregular, as was found to be the case for considerable of the portion immediately west of the stream control conduit, the two cut-offs will be provided, but the remainder of the concrete will be placed as best meets the conditions, and the higher projections of the rock bottom, if sound, may be left with no concrete covering.

Construction was begun on a small portion of the Main Dam in January, 1917, under Contract 3, which provided in part for the work necessary to divert the river and which contemplated completion on October 31 of the same year. War was declared in April, 1917, and owing to the delays occasioned thereby, work on this contract was not completed until December 23, 1918. A second contract, No. 11, was entered into in April, 1919, for the completion of the river diversion and for a variety of other work essential to securing the rapid prosecution of construction following the later letting of the major contract. It was expected to complete work on Contract 11 on December 31, 1919, but owing mainly to labor difficulties this contract was not completed until November 1, 1920. With the completion of the stream control work under these two contracts the river was diverted into the horseshoe shaped concrete conduit, 25 ft. wide by 21 ft. 4 in. high and 462 ft. long, built in solid rock across the foundation of the Main Dam. The approach channel lined on bottom and sides with concrete and about 1 000 ft. long and the discharge channel about 200 ft. long completed the river diversion channel, into which the river was turned on November 5, 1919. Portions of the up and downstream cofferdams were built and about 500 ft. of foundation of the dam immediately west of the river diversion conduit was uncovered, the ledge rock grouted and the trench refilled to the original surface with impervious material. The aggregate value of contract work done on the Main Dam prior to the letting of Contract 8, which provides for the completion of this work, was about $278 000.

Contract 8 for the Main Dam and Dike was executed on May 12, 1921. A schedule of the bids received for this contract is appended. The Contractors, Winston & Co., Inc., erected an excellent camp on an area of about 18 acres of sandy ground situated about ½ mile south of the dam. The camp houses a population of about 400 and is supplied with a suitable water supply, electric lights, plumbing for kitchen, laundry, sinks, etc. the drainage from which is satisfactorily disposed of in cesspools; provision

is made for incineration of garbage, and the Kaustine system is used for disposal of human excreta. A thoroughly equipped hospital with attendants is provided at the camp. Some of the sanitary provisions of the contract are as follows:

*General Requirements.* The Contractor and his employees shall promptly and fully carry out the sanitary and medical requirements as hereinafter described or as may from time to time be promulgated by the Engineer to the end that the health of his employees, of the local communities and of the people using water from the drainage areas affected by his operations may be conserved and safeguarded. The Contractor shall also obey regulations and orders of the properly constituted authorities, Municipal and State. The Contractor shall summarily dismiss and shall not again engage, except with the written consent of the Engineer, any employee who violates the sanitary and medical requirements; nor shall any person be employed, without the written consent of the Engineer, who is known to have violated the sanitary regulations on other works of the City.

*Inspection.* The Engineer shall have the right, in order to determine whether the requirements of this contract as to sanitary matters are being complied with, to enter and inspect any camp or building or any part of the works, and to cause any employee to be examined physically or medically or to be vaccinated or otherwise treated; also to inspect the drinking water and food supplied to the employees.

*Quarters and Stables.* The Contractor shall provide suitable and satisfactory buildings for the housing, feeding and sanitary necessities of the men, and suitable stabling for animals, employed upon the work. All buildings for these or kindred purposes shall be built only in accordance with approved drawings and specifications. All houses occupied by employees shall be thoroughly screened to exclude mosquitoes and flies. The quarters for the men shall be grouped in properly arranged camps located downstream from the proposed dam. The Contractor shall submit the locations proposed for his camps, buildings, and sanitary works to the Engineer for approval, whether located on the land of the City or elsewhere, and no such structures shall be erected until such approval shall have been obtained.

*Sanitary Conveniences and Disposal of Excreta.* Buildings for the sanitary necessities of all persons employed on the work, beginning with the first men employed to build camps or for other preliminary operations, shall be constructed and maintained by the Contractor in the number, manner and places ordered. These conveniences shall be of an approved chemical or an approved incinerator type, except that closets having watertight removable receptacles may be used in special cases, if and as permitted. Satisfactory precautions shall be taken to render the interior of the closest inaccessible to flies. The requirements for sanitaries in any locality shall be on a basis of not less than one unit for each 20 persons, including both those on duty and those in camp off duty, who are dependent on the sanitaries in the locality in question; it being further stipulated that the required number are always reasonably near the work, and that incinerators, if used, are always in sufficient number in any locality to permit a reasonable proportion to be out of service for the daily incineration of their contents. The Contractor shall rigorously prohibit the committing of nuisances upon land of the City or adjacent private property.

*Medical and Surgical Attendance.* The Contractor shall retain the services of one or more acceptable, qualified physicians, who shall reside at the work and have the care of his employees, shall inspect their dwellings, the stables and the sanitaries as often as required, and shall supply medical attendance and medicines to the employees whenever needed. The Contractor shall provide at the works from approved plans, a building

properly fitted for the purpose of a hospital, with facilities for heating and ventilating in cold weather, and for screening and ventilating in warm weather. This hospital shall be provided with all necessary medicines and medical appliances for the proper care of the sick and injured. At such places as directed all articles necessary for giving "First aid to the Injured," shall be provided.

*Medical Supervision of Employees; Reports.* The medical supervision of the Contractor over his employees shall extend to the physical and medical examination of all applicants for employment, in order to prevent persons having communicable diseases from becoming connected with the work, and the Contractor shall employ only persons shown by such examination to be free from communicable diseases. Any employee having a communicable disease shall be removed, when and as directed, to an approved permanent hospital. Whenever, in the opinion of the Engineer, it is necessary for the protection of the public health or the health of the employees, the Contractor shall remove any employee either to a hospital or permanently from the work or camp. Once each week, if required, the Contractor shall give the Engineer, in such detail as may be prescribed from time to time, a written report, signed by a physician in regular attendance, setting forth clearly the health condition of the camp or camps and of the employees. If any case of communicable disease be discovered, or any case of doubtful diagnosis, it shall be reported at once to the Engineer, by telephone or messenger, and confirmed in writing.

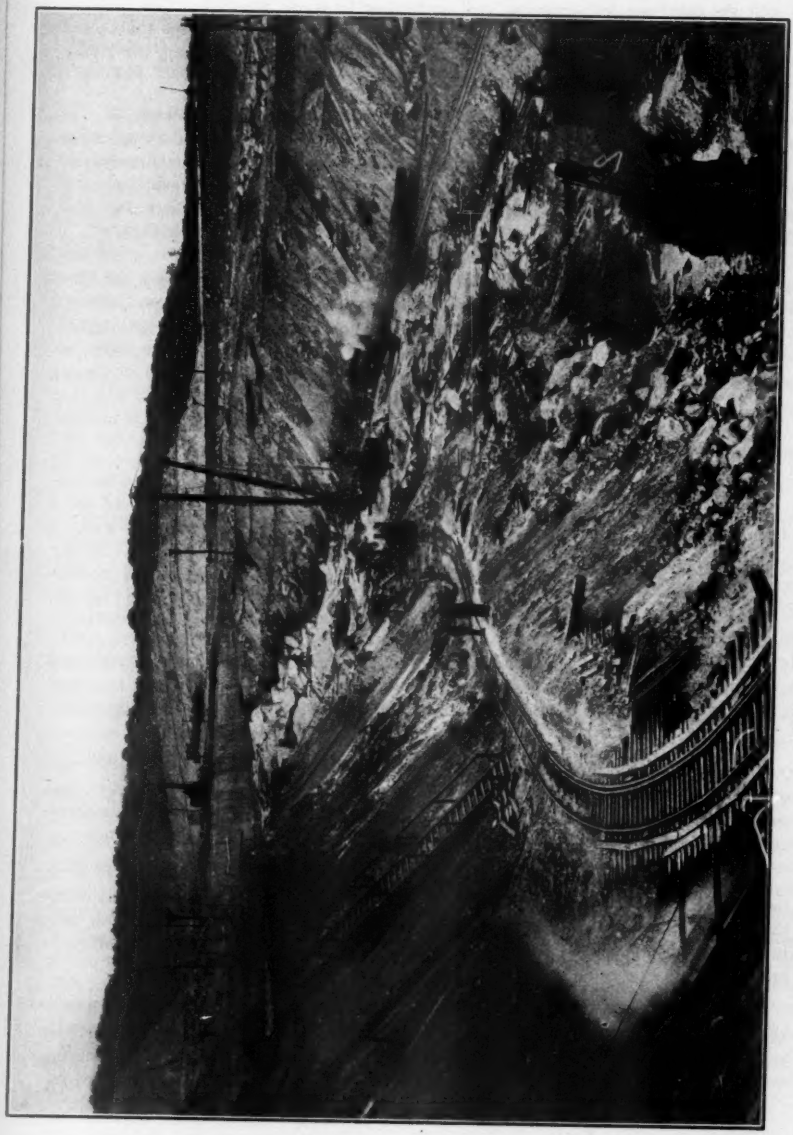
*Domestic Water Supply.* The water furnished by the Contractor shall include a sufficient supply of drinking water of acceptable quality for all his employees, to be obtained from approved sources. He shall provide ample bathing and clothes-washing facilities for his employees and sufficient water of acceptable quality therefor. If any water supply for domestic use should become contaminated, the contractor shall promptly provide a new supply from an approved source and abandon the contaminated supply, or shall provide works for purifying the contaminated water, when and as ordered.

*Treatment of Drainage.* Drainage from kitchens, laundries, sinks, baths, and stables shall be conducted in tight drains or other satisfactory conveyors to approved points of disposal where it will filter through the ground before entering any watercourse.

*Disinfectant and Fumigation.* The Contractor shall supply corrosive sublimate, quick lime, sulphur and other disinfectants and fumigants in ordered quantities, and perform the labor necessary to apply these materials when and as directed in disinfecting and fumigating camp and other buildings and disinfecting stables or grounds.

*Garbage Disposal.* Garbage, both liquid and solid, shall be promptly and satisfactorily removed from the building and immediately placed in approved tight receptacles of sufficient capacity of about one day's ordinary production. At least once in every twenty-four hours all such garbage shall be incinerated or otherwise thoroughly and satisfactorily disposed of in an approved manner.

*Care of Stables.* Manure will not be permitted to accumulate upon the premises but must be removed daily to an approved distance or daily incinerated. Removable stall racks shall be provided to permit thorough cleaning.



MAIN DAM, SCITUATE RESERVOIR.

Rock uncovered in bottom of core trench east of stream control conduit, shown towards the left. Upstream cofferdam shows at the top towards the right. Low point of excavation is about 70 feet below former river bed. Contract 8, June 1, 1922.

Excavation for deep portion of core trench is about 70 feet below former river bed. Contract 8, June 1, 1922.

MAIN DAM, SCITUATE RESERVOIR.

Excavation for deep portion of core trench, looking northeast showing upstream cofferdam at top, and track system with switchback. Contract 8, June 1, 1922.

The construction of a standard gage railroad about 2.3 mi. long, connecting the N.Y., N.H. & H. Railroad at Jackson with the dam, was completed on August 13, 1921. A high tension power line about 1 mile in length connecting the Narragansett Electric Lighting Company's line with the work at the dam was completed September 28, 1921. Electric current is used for lighting, pumping, for operating machine shop and saw mill and for a variety of other purposes. The contractor's equipment in use at the dam consists mainly of 3-ft. gage cars and locomotives, large and small steam shovels, small drag line excavators, steam rollers, one 12-ton traveling cable way, crossing the deep excavation transversely, directly connected electrically driven pumps with a total capacity of about 9 million gallons daily against a lift of about 80 ft., pumps, tanks and piping for water supply, compressor, grouting machine, bottom dumping wagons, mules and the usual rock drills and small tools. The excavation for the deepest portion of the core trench was completed, the foundation grouted

MAIN DAM, SCITUATE RESERVOIR.

Core trench looking west towards stream control conduit. Sump in foreground is deepest point of foundation, about 80 feet below original surface. Pump machine shows under canvas covering in right foreground. Soil core being started part way up slope. Contract 8, August 14, 1922.

and refilling begun in August, 1922. In order to keep the deep portion of the core trench unwatered, extensive pumping was necessary as shown in a later tabulation. The average side slopes of the excavation for the deep portion of the cut-off trench are about 2 horizontal to 1 vertical and the heavy shovels were operated when necessary, and without serious difficulty, in very fine sand with the line of saturation practically at its surface. The material in the excavation was very variable in stratification and unwatering was accomplished by open sumps below the general level of the excavation in locations where the material was coarse and from which the

water was pumped. In one instance the excavation of a sheeted pump well through fine sand to coarse underlying strata shown by the borings was attempted and after a considerable expenditure of time and money was given up because the running in of the sand rendered its excavation practically impossible by the ordinary methods which were available. This same sand, when relieved of upward water pressure by tapping the coarse material at some point below it, stands up at a steep slope. Had the very fine portions of the materials to be excavated been deposited in horizontal strata, more difficulty would have been experienced in excavation, but with this material existing in pockets, even though some of them were very large, little difficulty was experienced, with the aid of the preliminary borings in selecting satisfactory sites for sumps. The prosecution of the work

MAIN DAM, SITUATE RESERVOIR.

Looking east along portion of core trench west of stream control conduit, showing placing of soil core. Contract 8, August 14, 1922.

has demonstrated fully to the writer that, with the material varying from very fine sand, extremely active under water pressure, to gravel and with boulders of all sizes up to several yards in volume, the method of excavation used is the best and most economical.

The experience so far gained has demonstrated that a rolled sand and gravel embankment in thin layers either side of the soil core would have been prohibitive in cost owing to the boulders in the material available.

The following tabulation gives various progress data regarding the excavation and pumpage from the deep portion of the dam foundation.

SCITUATE DAM. PUMPAGE AND EXCAVATION FOR DEEP PORTION OF FOUNDATION.

| Date. | Average Weekly Pumpage Million Gals. Daily. | Vertical Projection of Area of Cut Below El. 200. (Approximate Original Ground Water Level) Sq. Ft. | Maximum Depth of Cut Below Elevation 200, Except at Sump Ft. | Total Excavation (Contract 8) Including 30 000 Cu. Yds. above Elevation 200 Cu. Yds. |
|---|---|---|---|---|
| Oct. 10, 1921 | .. | 8 800 | 12 | 62 600 |
| 15 | 1.5 | .. | .. | .. |
| 22 | 1.3 | .. | .. | .. |
| 29 | 1.7 | .. | .. | .. |
| Nov. 5 | 1.7 | .. | .. | .. |
| 10 | .. | 12 700 | 24 | 80 690 |
| 12 | 1.9 | .. | .. | .. |
| 19 | 2.1 | .. | .. | .. |
| 26 | 2.2 | .. | .. | .. |
| Dec. 3 | 2.4 | .. | .. | .. |
| 10 | 2.6 | 16 700 | 24 | 125 600 |
| 17 | 2.9 | .. | .. | .. |
| 24 | 3.0 | .. | .. | .. |
| 31 | 3.1 | .. | .. | .. |
| Jan. 7, 1922 | 3.1 | .. | .. | .. |
| 10 | .. | 19 900 | 31 | 151 000 |
| 14 | 3.7 | .. | .. | .. |
| 21 | 4.1 | .. | .. | .. |
| 28 | 3.4 | .. | .. | .. |
| Feb. 4 | 3.6 | .. | .. | .. |
| 10 | .. | 25 300 | 36 | 181 900 |
| 11 | 3.7 | .. | .. | .. |
| 18 | 3.7 | .. | .. | .. |
| 25 | 3.8 | .. | .. | .. |
| Mar. 4 | 3.8 | .. | .. | .. |
| 10 | .. | 30 600 | 41 | 208 800 |
| 11 | 3.9 | .. | .. | .. |
| 18 | 3.9 | .. | .. | .. |
| 25 | 4.0 | .. | .. | .. |
| Apr. 1 | 4.2 | .. | .. | .. |
| 8 | 4.1 | .. | .. | .. |
| 10 | .. | 34 400 | 45 | 230 400 |
| 15 | 4.8 | .. | .. | .. |
| 22 | 4.5 | .. | .. | .. |
| 29 | 3.9 | .. | .. | .. |
| May 6 | 3.7 | .. | .. | .. |
| 10 | .. | 38 600 | 54 | 248 300 |
| 13 | 4.5 | .. | .. | .. |
| 20 | 4.7 | .. | .. | .. |
| 27 | 4.6 | .. | .. | .. |
| June 3 | 4.3 | .. | .. | .. |
| 10 | 4.4 | 41 300 | 64 | 263 600 |
| 17 | 4.2 | .. | .. | .. |
| 24 | 4.3 | .. | .. | .. |
| July 1 | 4.3 | .. | .. | .. |
| 8 | 4.3 | .. | .. | .. |
| .. | .. | 43 300 | 71 | 272 200 |
| 15 | 4.6 | .. | .. | .. |
| 22 | 4.4 | .. | .. | .. |
| 29 | 5.6* | .. | .. | .. |
| Aug. 5 | 6.1* | .. | .. | .. |
| 10 | .. | 44 400 | 74 | 280 300 |
| 12 | 5.4 | .. | .. | .. |
| 19 | 4.6 | .. | .. | .. |
| 26 | 4.9 | .. | .. | .. |
| Sept. 2 | 5.0 | .. | .. | .. |

*Probably too large, as water pumped contained much fine sand and quantity is based on pump hours.

*Preparation of Rock Foundation.* After the earth and boulders have been removed from the core trench the top of the ledge rock is excavated to the extent directed without the use of explosives, the object being to remove so far as possible all seamy, broken and disintegrated rock such as would permit the flow of water from the upstream side of the dam after completion. The entire width of exposed rock bottom is then thoroughly cleaned and scrupulously freed from all dirt, gravel, boulders, loose fragments, etc., streams of water under sufficient pressure, stiff brushes, hammers and other effective means being used to accomplish this cleaning. The full ordered width of the bottom of the trench then receives special treatment by raking out all remaining seams and cavities and filling them with grout or mortar.

The middle portion of the core trench about 30 ft. in width is then covered or leveled up to the extent directed from place to place with concrete, the purpose being to fill the larger irregularities of the bottom, to facilitate the grouting and placing of the soil core and to seal exposed joints and seams in the rock bottom. There are also generally two low concrete cut-off walls near either edge of the 30-ft. strip which break the continuity of the contact between the rock and the soil core. The rock bottom exposed is generally very irregular and the concrete and the walls are placed so as to best meet the conditions encountered, there frequently being no concrete over high projections of the bottom and the concrete walls being omitted in places where they would serve no useful purpose. Sometimes before and sometimes after, placing the concrete, holes are drilled for grouting.

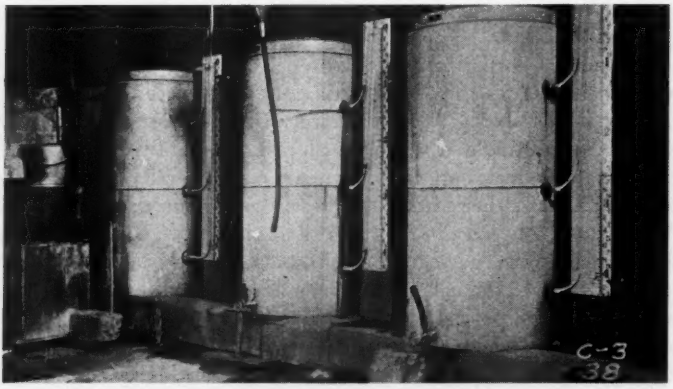
These holes generally do not extend more than 20 ft. into the rock but occasionally holes for test grouting and for other purposes are drilled to considerably greater depths.

Steel pipes with standard couplings, plugs and other fittings, are set in the rock or masonry where required so as to give water-tight joints to which the grouting machine is connected. The apparatus for mixing and placing grout is imounted on wheels with a direct connected engine, and consists essentially of an air-tight chamber in which the grout is mechanically stirred and from which it is forced by air pressure into the voids. The grout is generally placed under low pressure, much of it at about 5 lb. to the square inch and little exceeding 20 lb. After a section of the cut-off trench has been grouted, deeper holes, generally 30 to 35 ft. in depth, are drilled at occasional points to test the completeness of the previous grouting. About half of the foundation for the dam has already been satisfactorily grouted.

*Tests of Materials for Core.* Tests were begun in 1917 of materials available for the impervious core of the dam. Those tests demonstrated top-soil and subsoil to be entirely satisfactory and were in close agreement with an extensive series of tests made upon top-soil by the Metropolitan Water Works of Massachusetts some 25 years ago, following which top-

soil was depended upon solely for watertightness in the construction of the north and south dikes of the Wachusett Reservoir. Experiments were made of the rate of percolation through large cans and through small cans, the apparatus for each of which is shown on accompanying photographs.

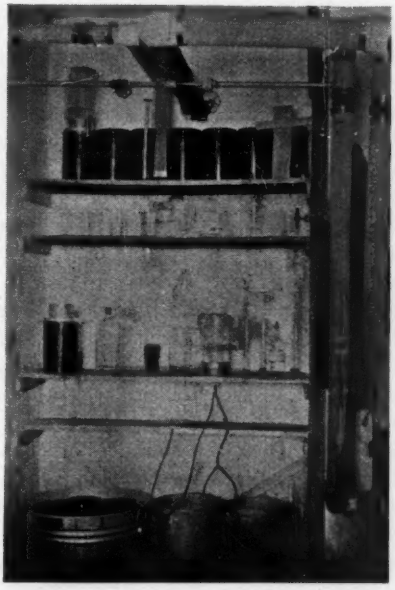
For the large can experiments, the apparatus consists essentially of four circular galvanized iron tanks each 2 ft. 4¼ in. in diameter and 5 ft. high, the sectional area being 1/10 000 of an acre. Near the bottom was a sill-cock. On the side of the tank were three perforations spaced 18 in. vertically on centers, with which were connected on the inside perforated




APPARATUS FOR LARGE CAN PERCOLATION TEST.

pipes traversing the material under test in the tank and on the outside glass gages. A waste vent was provided near the top of the tank. The tanks were filled in the following manner: At the bottom was placed a 5-in layer of pervious material graduating up from coarse gravel at the bottom to medium sand at the top. Directly on top of this was placed the material to be tested. This material had a total depth, or thickness, of 3 ft. 8 in. and on top of this was placed a 1-in. layer of coarse sand. The material to be tested was put into the tank in quantities such that with energetic tamping it was consolidated into layers from 1½ to 2 in. in thickness. Water was let into the tanks from the bottom by attaching to the sill-cock a piece of rubber garden hose connecting with a funnel suspended so as to give a moderate head. As it appeared advisable this funnel was raised until water appeared on the surface of the sand near the top of the tank. Water was then admitted to the open top of the tank, the level being kept constant by an overflow. The rubber hose was then removed from the sill-cock and the water allowed to percolate through the material as it would. It was the endeavor, however, to keep the flow such that the loss of head between the top and bottom perforated pipes would be approximately three feet. To accomplish this there was attached to the sill-cock

a short piece of garden hose, the end of which was raised or lowered as desired, thereby reducing or increasing the total effective head. The material under observation in the tanks was traversed at three places by perforated pipes leading to the connections at the sides of the tank and through them connected with glass tubes placed against a gage board. The perforations in these pipes were about $\frac{1}{8}$ in. in diameter and spaced in two diametrically opposite straight lines at about three inches center to center. At first these pipes were wrapped with a copper mosquito netting having 8 or 10 meshes to the inch, but upon disassembling the first tank



APPARATUS FOR SMALL CAN PERCOLATION TEST.

the pipes were found nearly filled with material. Thereafter each pipe was covered with copper screening of 100 meshes to the inch carefully soldered to the pipe, with the result that practically no material entered the pipes. Pieces of rubber garden hose connected the pipes with the stiff connections through the wall of the tank. These connections were in turn joined to the glass tubes by white rubber tubing, care being taken that it made a sharp slope upward to the bottom of the glass tube. This was calculated to permit easy egress for air bubbles and was adopted only after considerable attention had been given to the removal of air from the pipes. In placing each perforated pipe in the tanks the material was tamped up to a slightly greater height than that required for the pipe. A groove was then

dug out of the compacted material, the pipe was put in place and leveled up and then the material carefully tamped around and over it. Difficulty was experienced in keeping these pipes level, but that is not felt to be a serious defect. The gage glasses were about $\frac{1}{2}$ in. in diameter. One gage board served for all three tubes in each tank and was graduated to hundredths of a foot with the zero at the top and approximately at the surface of the water in the tank. The total loss of head at the different levels in the tank was therefore easily read at a glance.

All materials were used just as dug from the fields except for thorough mixing and the addition at times of water. Mixing consisted of the shoveling from the pit into the wagon, the shoveling out of the wagon and at least three complete turns on the floor. No frozen material was used and all lumps were carefully broken down. In the case of the gravelly material used in Experiment 4-C great care was taken to see that the stones did not sort themselves out in the handling. In packing all the tanks it was the practice to have the porous layer at the bottom of the tank full of water before the test material was placed to any extent. This was to do away with the considerable pocket of air that could have been moved only upward through the entire mass of the material or possibly through the three perforated pipes.

Considerable difficulty was experienced from time to time throughout the experiments with entrained air and it is probable that some of the otherwise unexplainable differences in results may be due to entrained air. The time available and the limitations of the apparatus did not permit pursuing to a final solution all the problems which arose. Difference in temperature was also important and the results have been reduced finally to a temperature of 50°F. There are doubtless other factors which may enter into a more refined consideration of the problem, such as atmospheric pressure which was considered but was disregarded. The results are believed to be sufficiently accurate for the purpose intended and are as good as it appeared practicable to obtain unless apparatus with very great refinement is used.

The small cans are about 9 in. high and 6 in. in diameter. The bottom of the can is covered with a half inch layer of porous sand. The material to be tested is then tamped in thin layers upon this to a total depth of 6 in. and the top covered with porous sand $\frac{1}{2}$ in. deep. A small hole through the bottom of the can into which is threaded a loose cord to control the drip provides the means for collecting the percolation and conducting it as required into a glass graduate. After filling, the cans were placed in a tub of water and the material saturated through the hole in the bottom in order to expel the air. In some of the experiments a device was used to increase the pressure while filling the small cans with water by sealing the tops of the cans and creating a partial vacuum on top of the sand, thus reducing the time of filling. Following saturation the cans were removed from the tub and filling over the top was begun. The arrangements for

insuring a constant head upon a series of tanks are indicated upon Plate IV and accompanying photograph. Parallel tests of the same materials in both large and small cans indicated a sufficiently close agreement to demon-

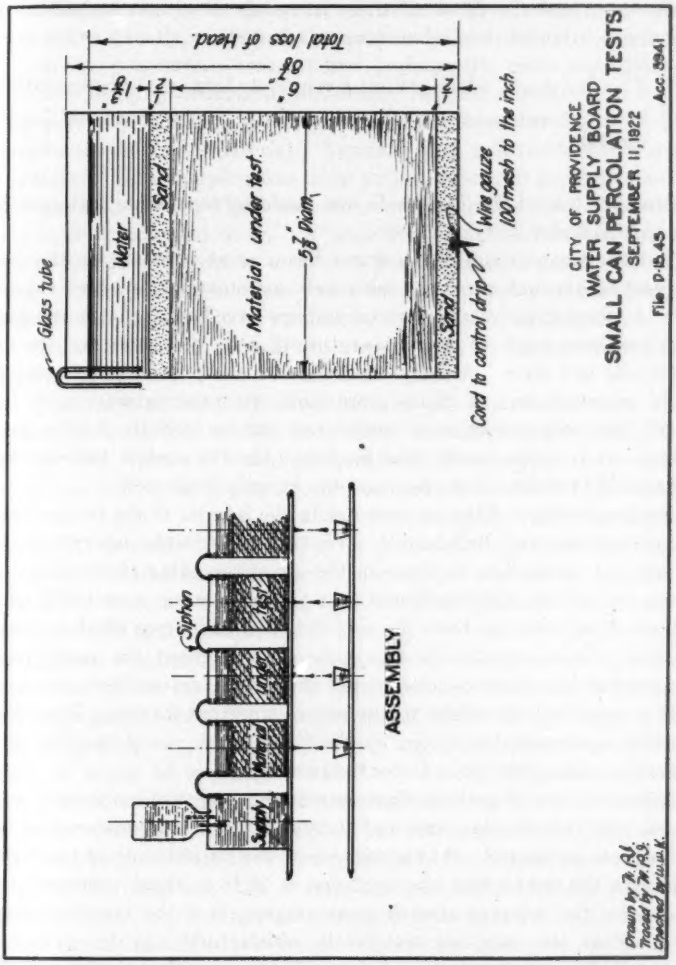



PLATE IV.

strate that the results from small can tests could be depended upon to indicate relative porosity within the limits of accuracy required. Tests with the small cans are therefore being kept up of the materials for core as they are being collected in the field and as they are being placed in the core.

## Results of Tests Made Prior to Adoption of Design of Dam Mainly Large Can Tests.

There are considerable masses of very fine sand in strata and pockets near the dam and the finest of these materials were also tested. The results plainly divided themselves into two classes:

(1) The fine sands, which permit a relatively large rate of percolation.

(2) The top soils and subsoils, which have a high degree of impermeability.

A further test of the fine sands was made by separating that portion only which passed a 200 mesh sieve.

That the temperature of the water has a great influence on the rate of percolation through sand has been well demonstrated in other experiments. In these experiments it would perhaps have been well if continuous records had been made of the temperature of both the water and the air but this was not done. A dairy thermometer was provided and read at frequent intervals and at times more elaborate observations as to the effect of the temperature were attempted but no definite results were achieved. It is undoubtedly true also that the barometric pressure has an appreciable influence but this has been entirely neglected.

The temperature of the air or water in the interior of the tank at any point or time was not determined. That changes in the interior of the tanks are not so marked as those in the air surrounding them or in the water on top of them, and that there is an appreciable lag, is probably true. Yet these outside changes form the only data available from which to make correction. Measures of flow accumulated throughout the night have been considered as check measurements only and have not been corrected for the reason that the night temperatures were not known. That this knowledge is necessary is shown by the fact that in every case the flow decreased at night due to the lower temperature.

In general two or perhaps three measurements were made each day, the total time between say nine and three o'clock, being consumed in the combined measurements. At the same time the temperature of the water standing in the tanks was observed and it is from these temperatures, averaged for the interval of each measurement, that the corrections are figured. That they are not completely satisfactory may be accounted for generally by an appreciation of the probable amount of the lag and the influence of this lag upon both the viscosity and the air entrained in the pores. In some of the early work the temperature of the water was not closely observed and in these cases the atmospheric temperature has been made use of.

The correction for temperature is figured by the formula derived by Allen Hazen, Past President of this Association, and stated in the *Annual*

*Report of the Massachusetts State Board of Health* for 1902, page 541. For application to the problem in hand it may be expressed as follows:—

Rate at 50°F = Observed Rate $\frac{(60)}{T+10'}$ T being the observed temperature.

As stated previously the value of T is more or less indeterminate but has been taken usually as that of the water standing on top of the tank.

Another uncertain element and perhaps the most uncertain of all, is in the difficulty of securing uniformity in placing material in the tanks. This probably accounts for much of the variations in duplicate tests of samples of the same material. Tamping and moisture control are most important. The tamping was done with a light iron rammer about 4 in. in diameter. It was lifted each time a comfortable height, about 9 in., and forcibly pounded down. A large heavy rammer was attempted but it was discarded almost at once as it jarred the tanks, even the adjacent ones, to such an extent that it was felt that possibly it was doing more damage than good. Under its use too the material would creep and break up around the edges. A uniform working all over the surface was decided upon as being best.

The most satisfactory condition and the one aimed at in all cases seemed to be in that middle zone where the material was damp and yet not too wet, where it would pack without breaking up or creeping and where the feeling on the handle of the rammer was that of a firm refusal with no "give" either of a dry crumbling or a soft mushy nature. Generally speaking it was felt to be in satisfactory condition when the surface after tamping became moist enough to feel "tacky". This could readily be detected by tapping with the feet when the tacky condition could be both heard and felt.

It was suggested that tamping in this condition brought about a separation of the materials with the result that the very finest particles were segregated into a film over the entire surface where they would form a layer so dense as possibly to preclude any percolation through it except where it might be imperfect or broken. In the tanks first packed and first dug out a tendency to such a segregation was shown by the fact that at places the layers were plainly to be observed and could be separated into definite planes but no tendency towards the formation of a film could be definitely observed. To obviate the possibility of this thereafter the surface of each layer, after being tamped, was scratched with a fine rake.

A variety of other interesting and, in some cases, not readily explainable phenomena developed during the progress of the tests but space does not permit of detailing them here. They are not believed to have an important bearing on the results and more refined apparatus would be necessary to account fully for many of them.

Results of large can experiments are given in the following tabulation. The difference between top-soil and subsoil can perhaps be best appreciated by quoting the definition given in the specifications for the Main Dam:

"Soil shall mean the material composing the surface layer of the ground which has been so affected by vegetable growth that it contains a considerable amount of organic matter" — page 17, Contract 8, etc.

| Experiment. | Duration Days. | Material. | Rate of Percolation. | Per cent. Passing 200 Sieve. | Per cent. Organic Matter Loss on Ignition. |
|---|---|---|---|---|---|
| 1 A | 50 | Mixed top-soil and subsoil | *15 300 | †58.1 | 3.67 |
| 2 A | 32 | | 8 600 | | |
| 1 B | 40 | Subsoil | 21 350 | 35.4 | 3.32 |
| 2 B | 38 | Subsoil and discolored fine sand | 3 200 | 38.1 | 3.46 |
| 3 B | 38 | Mixed top-soil and subsoil | 1 500 | 56.9 | 7.00 |
| 4 B | 30 | „ „ „ „ | 2 200 | 60.4 | 5.21 |
| 1 C | 11 | Topsoil (Grass roots in) | 10 800 | 38.6 | 5.74 |
| 2 C | 11 | „ ( „ „ out) | 10 000 | 36.9 | 4.80 |
| 3 C | 18 | Fine discolored sandy subsoil | 11 700 | 48.0 | 4.12 |
| 4 C | 25 | Gravelly subsoil | 6 300 | 22.6 | 3.01 |
| 3 A | 15 | Superfine white sand | 514 000 | 26 | 0.0 |
| 4 A | 10 | | 387 000 | | |

Tests in small cans of material tested in large can experiments 3A and 4A above gave a rate of 579 000 gal. per acre as compared with 514 000 and 387 000. A test of the portions of this material passing a 200-mesh sieve gives 200 500 gal. per acre. Two tests each in small cans of material tested in large can experiments 1B and 2B gave following results:

| | |
|---|---|
| 1B Large Can | 21 350‡ |
| Small can No. 5 | 4 500 |
| Small can No. 6 | 3 200 |
| 2B large can | 3 200 |
| Small can 13 | 3 800 |
| Small can 14 | 3 200 |

Following is a tabulation of small can tests made during construction, mainly to demonstrate the quality of material proposed for or used in the core. Tests run from 6 to 10 days.

REJECTED OR FOR OTHER REASONS NOT USED.

| Date. | Percolation. | Material. |
|---|---|---|
| July — Aug. 1920 | 53 000 | Coarse sand mixed with top soil in core. |
| July — Aug. 1920 | 115 000 | Discolored coarse sand under top soil in core. |
| July — Aug. 1920 | 15 000 | Very fine sand (rock flour) occurring in a thin streak in core trench — not available for and not used in core. |
| July — Aug. 1920 | 8 300 | Dark top soil and subsoil with some silt. Very little used in core. |

*Gallons per acre per day figured as for 1 : 1 slope, from data on the total loss of head and corrected for temperature.

†Only that portion of material passing No. 10 sieve considered.

‡This was the first large can to be filled with soil and the rate of percolation is undoubtedly higher than would have obtained in later work after experience had been gained in the consolidation of the material.

| | | |
|---|---|---|
| Aug. 1921 | 33 000 | Very fine white sand which occurred in small quantities in cut-off trench. |
| Aug. 1921 | 42 000 | Coarse sandy subsoil. |
| Nov. 1921 | 25 000 | Coarse sandy subsoil. |
| April 1922 | 20 000 | Coarse sandy subsoil. |
| April 1922 | 13 000<br>8 000 | Very fine sand below subsoil. |
| May 1922 | 6 000<br>2 200 | Very fine sand below subsoil. |
| May 1922 | 4 000 | Material under subsoil. |
| Aug. 1922 | 21 000 | Retest of same material as above (first test appears to have been in error.) |
| Aug. 1922 | 66 000<br>65 000 | Coarse loamy material from storage pile. |

ACCEPTABLE AND USED OR TO BE USED IN CORE.

| | | |
|---|---|---|
| Aug. 1921 | 10 000 | Top soil and subsoil. |
| Aug. 1921 | 11 000 | Subsoil. |
| Sept. 1921 | 9 000 | Subsoil. |
| Sept. 1921 | 4 000 | Subsoil |
| Sept. 1921 | 9 000 | Subsoil. |
| Sept. 1921 | 3 000 | Subsoil. |
| Oct. 1921 | 1 200 | Top soil and subsoil from storage pile. |
| Oct. 1921 | 2 000 | Top soil and subsoil from storage pile. |
| Oct. 1921 | 3 000 | Top soil and subsoil from storage pile. |
| Nov. 1921 | 5 300 | Subsoil. |
| April 1922 | 12 000 | Top soil. |
| April 1922 | 17 000 | Subsoil. |
| April 1922 | 9 000 | Top soil. |
| April 1922 | 18 000 | Subsoil |
| April 1922 | 40 000 | Top and subsoil. This is evidently a poor test as appearance of material is excellent and is similar to that tested in following two tests. |
| April 1922 | 2 000<br>11 000 | Top soil and subsoil from storage pile. |
| April 1922 | 1 400<br>1 300 | Top soil and subsoil from storage pile. |
| May 1922 | 400<br>1,400 | Top soil and subsoil from storage pile. |
| May 1922 | 300<br>900 | Top soil and subsoil from storage pile. |
| May 1922 | 1 300<br>900 | Top soil and subsoil from storage pile. |
| May 1922 | 1 200<br>1 000 | Top soil and subsoil from storage pile. |
| May 1922 | 1 700<br>1 400 | Top soil and subsoil from storage pile. |
| May 1922 | 6 300<br>1 600 | Subsoil in place. |
| Aug. 1922 | 2 400<br>525 | Top soil and subsoil from storage pile. |

| | | |
|---|---|---|
| Aug. 1922 | 1 200<br>14 000 | Top soil and subsoil from storage pile. |
| Aug. 1922 | 270<br>700 | Top soil and subsoil. |
| Aug. 1922 | 680 | Top soil and subsoil from storage pile. |
| Aug. 1922 | 2 600<br>1 800 | Black top soil. |
| Aug. 1922 | 2 200<br>2 600 | Top soil and subsoil. |
| Aug. 1922 | 11 000<br>13 000 | Top soil. |
| Aug. 1922 | 5 000<br>5 000 | Subsoil underlying above top soil. |
| Aug. 1922 | 4 000<br>2 000 | Mixture of above top and subsoils. |

SAMPLES OF MATERIAL ACTUALLY TAKEN FROM SOIL CORE AFTER PLACING.

| | | | Station. | Elevation. |
|---|---|---|---|---|
| Aug. 17, 1920 | 2 000 | Core of Dam | 22+00 | 216.5 |
| Aug. 17, 1920 | 2 400 | Core of Dam | 21+00 | 209.0 |
| Aug. 17, 1920 | 2 200 | Core of Dam | 20+00 | 207.0 |
| Aug. 25, 1920 | 2 400 | Core of Dam | 21+50 | 213.1 |
| Aug. 25, 1920 | 1 800 | Core of Dam | 20+50 | 211.0 |
| Aug. 25, 1920 | 1 800 | Core of Dam | 19+50 | 206.3 |
| Aug. 30, 1920* | 9 000 | Core of Dam | | |
| Sept. 1, 1920 | 2 000 | Core of Dam | 20+00 | 213.0 |
| Sept. 1, 1920 | 2 000 | Core of Dam | 21+00 | 213.5 |
| Sept. 1, 1920 | 2 000 | Core of Dam | 22+00 | 216.0 |
| Sept. 11, 1920 | 2 000 | Core of Dam | 20+50 | 216.4 |
| Sept. 11, 1920 | 2 000 | Core of Dam | 21+50 | 215.8 |
| Sept. 11, 1920 | 3 000 | Core of Dam | 22+50 | 219.6 |

Mechanical analyses were made of materials tested in the large cans and also of those used in a considerable number of the small can experiments. In some of the later work the elutriation method has been used to determine the smaller grain sizes. It has not yet been possible to make positive deductions from these tests, which are being continued.

It is the writer's tentative opinion that the sizes and proportions of the grains account for the high degree of imperviousness in soils and that the organic content has little if any relation thereto. It is probable that experiments of a more refined character may be required to establish the relation between imperviousness and the sizes and proportions of the particles.

The loss of water through the dam as designed, if core materials having an average rate of percolation of 10 000 g.d. were used, would be

*This sample was of a very small quantity of material delivered at core the appearance of which indicated it to be of doubtful suitability for which reason the test was made. The sample was obtained by scraping from the surface what appeared to be the most pervious material which could be found. This is believed to be the most pervious material so far used in the core and as the quantity used is negligible an average porosity is represented by the other samples.

| Item. | Description. | Quantity and Unit. | *WINSTON & CO., INC., 240 Fair Street, Kingston, N. Y. | | WILSON & EN CONSTRUCTIO 50 Church S New York City, | |
|---|---|---|---|---|---|---|
| | | | Price. | Amount. | Price. | A |
| 1 | Clearing | 200 Acres | $65.00 | $13 000 | $250.00 | |
| 2 | Grubbing | 10 Acres | 200.00 | 2 000 | 300.00 | |
| 3 | Removal of soil | 40 000 Cu. yd. | 0.90 | 36 000 | 1.50 | |
| 4 | Earth excav. in open trench for dam above El. 195, etc. | 260 000 Cu. yd. | 0.85 | 221 000 | 0.90 | |
| 5 | Earth excav. in open trench for dam between El. 195-160. | 220 000 Cu. yd. | 1.90 | 418 000 | 1.00 | |
| 6 | Earth excav. in open trench for dam below El. 160 | 60 000 Cu. yd. | 2.40 | 144 000 | 1.90 | |
| 7 | Earth excavation in sheeted trench | 1 000 Cu. yd. | 2.90 | 2 900 | 15.00 | |
| 8 | Rock excavation where blasting is permitted | 50 000 Cu. yd. | 2.95 | 147 500 | 3.50 | |
| 9 | Rock excavation where blasting is not permitted | 7 000 Cu. yd. | 5.90 | 41 300 | 8.00 | |
| 10 | Pumping from core trench of main dam | Lump sum | ..... | 59 000 | ..... | |
| 11 | Refilling and embanking of soil in 6-inch layers | 600 000 Cu. yd. | 1.00 | 600 000 | 2.00 | 1 |
| 12 | Refilling of pervious materials for dam below El. 195 | 150 000 Cu. yd. | 0.65 | 97 500 | 1.00 | |
| 13 | Refilling and embanking of pervious materials above El. 195 | 2 000 000 Cu. yd. | 0.49 | 980 000 | 0.65 | 1 |
| 14 | Miscellaneous refilling and embanking | 30 000 Cu. yd. | 0.80 | 24 000 | 1.00 | |
| 15 | Soil dressing | 75 000 Cu. yd. | 0.80 | 60 000 | 1.75 | |
| 16 | Grassing | 40 Acres | 50.00 | 2 000 | 200.00 | |
| 17 | Concrete | 15 000 Cu. yd. | 7.20 | 108 000 | 9.00 | |
| 18 | Concrete | 5 000 Cu. yd. | 14.00 | 70 000 | 15.00 | |
| 19 | Reinforced concrete | 1 500 Cu. yd. | 30.00 | 45 000 | 20.00 | |
| 20 | Surface finish of concrete by scrubbing with acid | 5 000 Sq. ft. | 0.10 | 500 | 0.10 | |
| 21 | Surface finish of concrete by tool dressing | 10 000 Sq. ft. | 0.20 | 2 000 | 0.15 | |
| 22 | Surface finish of concrete by granolithic finish | 3 000 Sq. ft. | 0.10 | 300 | 0.10 | |
| 23 | Reinforced concrete ladders | 100 Lin. ft. | 4.00 | 400 | 10.00 | |
| 24 | Grout | 5 000 Cu. yd. | 5.80 | 29 000 | 4.00 | |
| 25 | Eight-inch vitrified pipe | 2 500 Lin. ft. | 1.00 | 2 500 | 1.00 | |
| 26 | Twelve-inch vitrified pipe | 250 Lin. ft. | 1.50 | 375 | 1.50 | |
| 27 | Eighteen-inch vitrified pipe | 1 500 Lin. ft. | 2.50 | 3 750 | 2.00 | |
| 28 | Portland cement | 35 000 Barrels | 3.00 | 105 000 | 4.00 | |
| 29 | Screened gravel or broken stone | 20 000 Cu. yd. | 2.50 | 50 000 | 2.50 | |
| 30 | Gravel surfacing for roads | 1 000 Cu. yd. | 2.50 | 2 500 | 3.00 | |
| 31 | Bituminous surfacing for roads | 20 000 Sq. yd. | 1.00 | 20 000 | 1.50 | |
| 32 | Heavy riprap | 35 000 Cu. yd. | 1.50 | 52 500 | 1.00 | |
| 33 | Light riprap | 50 000 Cu. yd. | 1.50 | 75 000 | 1.00 | |
| 34 | Paving and dry masonry | 1 000 Cu. yd. | 6.50 | 6 500 | 3.00 | |
| 35 | Stone walls | 7 000 Lin. ft. | 2.50 | 17 500 | 2.00 | |
| 36 | Drilling holes in rock and masonry | 10 000 Lin. ft. | 0.70 | 7 000 | 0.50 | |
| 37 | Steel for reinforcing concrete | 150 000 Pounds | 0.06 | 9 000 | 0.08 | |
| 38 | Cast iron grooves | 70 000 Pounds | 0.06 | 4 200 | 0.07 | |
| 39 | Miscellaneous steel and iron | 100 000 Pounds | 0.08 | 8 000 | 0.12 | |
| 40 | Galvanizing | 10 000 Pounds | 0.02 | 200 | 0.10 | |
| 41 | Caring for and setting cast iron pipe furn. by City | 300 Tons | 40.00 | 12 000 | 20.00 | |
| 42 | Caring for and setting metal-work other than above | 100 Tons | 60.00 | 6 000 | 40.00 | |
| 43 | Timber and lumber | 10 M ft. B.M. | 120.00 | 1 200 | 150.00 | |
| 44 | Wooden guard rails | 5 000 Lin. ft. | 0.60 | 3 000 | 1.00 | |
| 45 | Waterproofing | 300 Sq. yd. | 1.00 | 300 | 2.00 | |
| 46 | Stream control and closure of conduit | Lump sum | ..... | 5 000 | ..... | |
| 47 | Cleaning up | Lump sum | ..... | 5 000 | ..... | |
| | | Totals | ..... | $3 499 925 | ..... | $4 |

*Awarded May 4, 1921. Notice to begin work dated May 23.

ROVIDENCE, WATER SUPPLY BOARD, SCITUATE RESERVOIR. CONTRACT 8, MAIN DAM AND DIKE.

ENED APRIL 27, 1921. CONTRACT EXECUTED WITH WINSTON & CO., INC., MAY 12, 1921.

| | *WINSTON & CO., INC., 240 Fair Street, Kingston, N. Y. | | WILSON & ENGLISH CONSTRUCTION CO., 50 Church Street, New York City, N. Y. | | RINEHART & DENNIS CO., INC., National Bank Bldg., Charlottesville, Va. | | C. W. BLAKESLEE & SONS, 58 Waverly St., New Haven, Conn. | | E. W. FOLEY CONST. CORP., 34 Pine St., New York, N. Y. | | MELLON STUART COMPANY 2112 Oliver Building Smithfield St., Pittsburg, Penna. | | ARTHUR G. McKEE & CO. 2422 Euclid Ave., Cleveland, Ohio. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unit. | Price. | Amount. | Price. | Amount. | Price. | Amount. | Price | Amount. | Price. | Amount. | Price. | Amount. | Price. | Amount. |
| res | $65.00 | $13 000 | $250.00 | $50 000 | $200.00 | $40 000 | $160.00 | $32 000 | $225.00 | $45 000 | $180.00 | $36 000 | $136.50 | $27 300 |
| res | 200.00 | 2 000 | 300.00 | 3 000 | 300.00 | 3 000 | 300.00 | 3 000 | 175.00 | 1 750 | 200.00 | 2 000 | 205.25 | 2 052 |
| . yd. | 0.90 | 36 000 | 1.50 | 60 000 | 1.00 | 40 000 | 1.00 | 40 000 | 1.50 | 60 000 | 1.25 | 50 000 | 1.02 | 40 800 |
| . yd. | 0.85 | 221 000 | 0.90 | 234 000 | 1.00 | 260 000 | 1.20 | 312 000 | 1.40 | 364 000 | 0.76 | 197 600 | 0.52 | 135 200 |
| . yd. | 1.90 | 418 000 | 1.00 | 220 000 | 1.25 | 275 000 | 1.45 | 319 000 | 3.25 | 715 000 | 1.43 | 314 600 | 0.60 | 132 000 |
| . yd. | 2.40 | 144 000 | 1.90 | 114 000 | 2.00 | 120 000 | 2.05 | 123 000 | 4.00 | 240 000 | 2.69 | 161 400 | 1.66 | 99 600 |
| . yd. | 2.90 | 2 900 | 15.00 | 15 000 | 5.00 | 5 000 | 10.00 | 10 000 | 15.00 | 15 000 | 9.50 | 9 500 | 8.20 | 8 200 |
| . yd. | 2.95 | 147 500 | 3.50 | 175 000 | 3.00 | 150 000 | 3.00 | 150 000 | 5.00 | 250 000 | 3.10 | 155 000 | 3.47 | 173 500 |
| . yd. | 5.90 | 41 300 | 8.00 | 56 000 | 5.00 | 35 000 | 10.00 | 70 000 | 9.00 | 63 000 | 6.00 | 42 000 | 7.30 | 51 100 |
| mp sum | ..... | 59 000 | ..... | 75 000 | ..... | 200 000 | ..... | 120 000 | ..... | 100 000 | ..... | 500 000 | ..... | 206 000 |
| . yd. | 1.00 | 600 000 | 2.00 | 1 200 000 | 1.50 | 900 000 | 2.25 | 1 350 000 | 2.00 | 1 200 000 | 1.82 | 1 092 000 | 2.25 | 1 350 000 |
| . yd. | 0.65 | 97 500 | 1.00 | 150 000 | 1.00 | 150 000 | 0.70 | 105 000 | 0.60 | 90 000 | 1.20 | 180 000 | 1.15 | 172 500 |
| . yd. | 0.49 | 980 000 | 0.65 | 1 300 000 | 0.75 | 1 500 000 | 0.55 | 1 100 000 | 0.65 | 1 300 000 | 0.99 | 1 980 000 | 1.04 | 2 080 000 |
| . yd. | 0.80 | 24 000 | 1.00 | 30 000 | 1.50 | 45 000 | 0.90 | 27 000 | 1.10 | 33 000 | 2.40 | 72 000 | 1.70 | 51 000 |
| . yd. | 0.80 | 60 000 | 1.75 | 131 250 | 1.50 | 112 500 | 2.00 | 150 000 | 1.40 | 105 000 | 1.65 | 123 750 | 3.07 | 230 250 |
| res | 50.00 | 2 000 | 200.00 | 8 000 | 50.00 | 2 000 | 120.00 | 4 800 | 80.00 | 3 200 | 175.00 | 7 000 | 136.50 | 5 460 |
| . yd. | 7.20 | 108 000 | 9.00 | 135 000 | 10.00 | 150 000 | 14.10 | 211 500 | 11.00 | 165 000 | 12.00 | 180 000 | 18.00 | 270 000 |
| . yd. | 14.00 | 70 000 | 15.00 | 75 000 | 16.00 | 80 000 | 17.50 | 87 500 | 16.00 | 80 000 | 14.00 | 70 000 | 26.00 | 130 000 |
| . yd. | 30.00 | 45 000 | 20.00 | 30 000 | 20.00 | 30 000 | 32.00 | 48 000 | 28.00 | 42 000 | 22.00 | 33 000 | 39.00 | 58 500 |
| . ft. | 0.10 | 500 | 0.10 | 500 | 0.50 | 2 500 | 0.20 | 1 000 | 0.20 | 1 000 | 0.19 | 950 | 0.08 | 400 |
| . ft. | 0.20 | 2 000 | 0.15 | 1 500 | 0.80 | 8 000 | 0.55 | 5 500 | 0.25 | 2 500 | 0.30 | 3 000 | 0.16 | 1 600 |
| . ft. | 0.10 | 300 | 0.10 | 300 | 0.50 | 1 500 | 0.20 | 600 | 0.35 | 1 050 | 0.20 | 600 | 0.27 | 810 |
| n. ft. | 4.00 | 400 | 10.00 | 1 000 | 10.00 | 1 000 | 2.50 | 250 | 3.50 | 350 | 2.00 | 200 | 2.70 | 270 |
| . yd. | 5.80 | 29 000 | 4.00 | 20 000 | 10.00 | 50 000 | 10.00 | 50 000 | 9.00 | 45 000 | 12.00 | 60 000 | 4.00 | 20 000 |
| n. ft. | 1.00 | 2 500 | 1.00 | 2 500 | 1.50 | 3 750 | 1.00 | 2 500 | 1.25 | 3 125 | 1.25 | 3 125 | 1.36 | 3 400 |
| n. ft. | 1.50 | 375 | 1.50 | 375 | 3.00 | 750 | 1.25 | 312 | 2.00 | 500 | 2.50 | 625 | 2.00 | 500 |
| n. ft. | 2.50 | 3 750 | 2.00 | 3 000 | 5.00 | 7 500 | 2.50 | 3 750 | 2.50 | 3 750 | 6.00 | 9 000 | 4.00 | 6 000 |
| rrels | 3.00 | 105 000 | 4.00 | 140 000 | 4.00 | 140 000 | 3.45 | 120 750 | 3.80 | 133 000 | 4.15 | 145 250 | 4.80 | 168 000 |
| . yd. | 2.50 | 50 000 | 2.50 | 50 000 | 3.00 | 60 000 | 5.00 | 100 000 | 2.50 | 50 000 | 2.75 | 55 000 | 3.05 | 61 000 |
| . yd. | 2.50 | 2 500 | 3.00 | 3 000 | 3.00 | 3 000 | 4.00 | 4 000 | 3.00 | 3 000 | 2.75 | 2 750 | 3.05 | 3 050 |
| . yd. | 1.00 | 20 000 | 1.50 | 30 000 | 2.00 | 40 000 | 1.40 | 28 000 | 2.50 | 50 000 | 4.00 | 80 000 | 1.77 | 35 400 |
| . yd. | 1.50 | 52 500 | 1.00 | 35 000 | 3.00 | 105 000 | 2.50 | 87 500 | 2.50 | 87 500 | 3.50 | 122 500 | 10.25 | 358 750 |
| . yd. | 1.50 | 75 000 | 1.00 | 50 000 | 2.00 | 100 000 | 2.50 | 125 000 | 2.25 | 112 500 | 4.40 | 220 000 | 3.05 | 152 500 |
| . yd. | 6.50 | 6 500 | 3.00 | 3 000 | 10.00 | 10 000 | 7.00 | 7 000 | 7.00 | 7 000 | 5.00 | 5 000 | 5.40 | 5 400 |
| n. ft. | 2.50 | 17 500 | 2.00 | 14 000 | 3.00 | 21 000 | 2.20 | 15 400 | 3.50 | 24 500 | 3.50 | 24 500 | 6.10 | 42 700 |
| n. ft. | 0.70 | 7 000 | 0.50 | 5 000 | 1.00 | 10 000 | 1.25 | 12 500 | 1.75 | 17 500 | 1.20 | 12 000 | 3.20 | 32 000 |
| unds | 0.06 | 9 000 | 0.08 | 12 000 | 0.07 | 10 500 | 0.075 | 11 250 | 0.10 | 15 000 | 0.07 | 10 500 | 0.07 | 10 500 |
| unds | 0.06 | 4 200 | 0.07 | 4 900 | 0.12 | 8 400 | 0.12 | 8 400 | 0.11 | 7 700 | 0.12 | 8 400 | 0.09 | 6 300 |
| unds | 0.08 | 8 000 | 0.12 | 12 000 | 0.10 | 10 000 | 0.16 | 16 000 | 0.10 | 10 000 | 0.16 | 16 000 | 0.17 | 17 000 |
| unds | 0.02 | 200 | 0.10 | 1 000 | 0.15 | 1 500 | 0.10 | 1 000 | 0.05 | 500 | 0.10 | 1 000 | 0.22 | 2 200 |
| ns | 40.00 | 12 000 | 20.00 | 6 000 | 50.00 | 15 000 | 50.00 | 15 000 | 40.00 | 12 000 | 15.00 | 4 500 | 70.00 | 21 000 |
| ns | 60.00 | 6 000 | 40.00 | 40 000 | 50.00 | 5 000 | 50.00 | 5 000 | 35.00 | 3 500 | 25.00 | 2 500 | 82.00 | 8 200 |
| ft. B.M. | 120.00 | 1 200 | 150.00 | 1 500 | 150.00 | 1 500 | 100.00 | 1 000 | 125.00 | 1 250 | 200.00 | 2 000 | 70.00 | 700 |
| n. ft. | 0.60 | 3 000 | 1.00 | 5 000 | 1.00 | 5 000 | 0.60 | 3 000 | 0.65 | 3 250 | 1.00 | 5 000 | 0.70 | 3 500 |
| . yd. | 1.00 | 300 | 2.00 | 600 | 3.00 | 900 | 2.00 | 600 | 5.00 | 1 500 | 6.00 | 1 800 | 2.75 | 825 |
| mp sum | ..... | 5 000 | ..... | 15 000 | ..... | 10 000 | ..... | 10 000 | ..... | 10 000 | ..... | 62 500 | ..... | 13 650 |
| mp sum | ..... | 5 000 | ..... | 5 000 | ..... | 25 000 | ..... | 5 000 | ..... | 5 000 | ..... | 20 000 | ..... | 6 875 |
| s | ..... | $3 499 925 | ..... | $4 487 425 | ..... | $4 754 300 | ..... | $4 903 112 | ..... | $5 483 925 | ..... | $6 084 550 | ..... | $6 205 992 |

1921. Notice to begin work dated May 23.

TABLE 2. — CONTRACT DATA.

TABLE 2. — CONTRACT DATA.

| Contract. | Description. | Contractor. | Bids Opened. | Date of Cont. | Final Estimate. | Date Completed. |
|---|---|---|---|---|---|---|
| 1 | Wash and core borings on sites of Dam and Aqueduct in the Town of Scituate and the City of Cranston | Sprague and Henwood, Inc., Scranton, Penn. | Dec. 22, 1915 | Dec. 27, 1915 | $13 082 22 | Sept. 20, 1916 |
| 2 | Continuation of Contract 1 | Sprague and Henwood, Inc., Scranton, Penn. | ..... | Sept. 20, 1916 | 5 333.69 | Jan. 25, 1917 |
| 3 | Stream control works for Main Dam including concrete conduit and earth approach channel | E. W. Foley Contracting Corp., New York City, N. Y. | Jan. 3, 1917 | Jan. 11, 1917 | 113 798.85 | Dec. 23, 1918 |
| 4 | 1.8 miles of gravel road from Plainfield Pike to Bald Hill Road (Portion of New East Road) | E. W. Foley Contracting Corp., New York City, N. Y. | Apr. 9, 1919 | Apr. 14, 1919 | 53 009.31 | Oct. 8, 1919 |
| 5 | 3.1 miles of gravel road south of Tunk Hill Road (Portion of New West Road) | Cenedella and Co., Milford, Mass. | May 12, 1920 | May 14, 1920 | 156 788.72 | July 7, 1921 |
| 6 | 1.75 miles of gravel road from Plainfield Pike to Rockland-Richmond Road (Portion of New West Road) | Louis Longhi and Bro., Inc., Torrington, Conn. | June 22, 1921 | July 1, 1921 | 55 939.67 | Dec. 7, 1921 |
| 7 | 3.4 miles of gravel road from Clayville to Plainfield Pike (Portion of Relocated Plainfield Pike) | The Sperry Eng. Co., New Haven, Conn., | Apr. 9, 1919 | Apr. 15, 1919 | 89 609.89 | Dec. 23, 1920 |
| 8 | Construction of the Main Dam and Dike and subsidiary works at Kent | Winston and Co., Inc., Kingston, N. Y. | Apr. 27, 1921 | May 12, 1921 | *3 499 925.00 | ..... |
| 9 | Regulating Dam and Reservoir at North Scituate | E. W. Foley Contracting Corp., New York City, N. Y. | Aug. 21, 1918 | Aug. 27, 1918 | 50 591.06 | Dec. 20, 1918 |
| 10 | 3.5 miles of gravel road from Danielson Pike to Plainfield Pike (Portion of New East Road) | Linberg and Street, Boston, Mass. | Apr. 23, 1919 | May 5, 1919 | 66 018.09 | June 7, 1920 |
| 11 | Completion of stream control works, approach and discharge channels and a portion of the Main Dam | The Sperry Eng. Co., New Haven, Conn. | Apr. 23, 1919 | Apr. 29, 1919 | 164 031.72 | Nov. 1, 1920 |
| 12 | New outlet works at Moswansicut Pond and other incidental work, at North Scituate | George T. Seabury, Inc., Providence, R. I. | Sept. 17, 1919 | Sept. 17, 1919 | 9 969.34 | Dec. 31, 1919 |
| 13 | Moswansicut River Bridge on the Danielson Pike at North Scituate | Thomas F. McGovern, Southbridge, Mass. | Sept. 15, 1920 | Sept. 28, 1920 | 47 968.26 | May 31, 1921 |
| 14 | Surfacing with bituminous macadam 3.4 miles of road graded under contract 7 (Relocated Plainfield Pike) | Perini and Sons, Inc., Ashland, Mass. | Nov. 17, 1920 | Nov. 17, 1920 | 100 858.46 | Nov. 9, 1921 |
| 15 | Grading & Surfacing 4.75 mi. of bituminous macadam road from Danielson Pike to Rockland (N. Scituate-R'land Rd.) | John Bristow, Narragansett Pier, R. I. | Oct. 5, 1921 | Oct. 11, 1921 | *258 647.50 | ..... |
| 16 | For moving the "King House" for use as the Dam and Aqueduct Division Office | Sweeney Bros., Inc., East Providence, R. I. | Aug. 3, 1921 | Aug. 9, 1921 | 1 200.00 | Oct. 1, 1921 |
| 17 | Alterations and repairs to the "King House" | Souther Construction Co., Providence, R. I. | Oct. 5, 1921 | Oct. 14, 1921 | 3 735.00 | Dec. 31, 1921 |
| 18 | Plumbing and heating the "King House" | Thomas I. Hudson, Providence, R. I. | Oct. 26, 1921 | Oct. 29, 1921 | 1 679.50 | Dec. 21, 1921 |
| 19 | Electric Installation at the "King House" | W. A. Huse and Son, Providence, R. I. | Nov. 9, 1921 | Nov. 16, 1921 | 610.00 | Jan. 5, 1922 |
| 20 | Plumbing and Heating "Powell" and "Yeaw" Houses at Kent | F. G. Lees and Son, Providence, R. I. | May 10, 1922 | May 15, 1922 | 1 014.00 | June 6, 1922 |
| 21 | 3.3 miles of Scituate Aqueduct (tunnel) in the Town of Scituate and the City of Cranston | Keystone State Construction Co. Philadelphia, Pa. | Aug. 30, 1922 | Sept. 20, 1922 | *1 318 340.00 | ..... |

* Basis of award, contract being uncompleted.

about 54 000 g.d., the quantity varying directly with the percolation rate of the material used. It is seen therefore that the core material used is exceptionally well fitted for the purpose.

This paper of necessity cannot cover some interesting features of the project which are as yet in the formative stage and it may at some future time be desirable to present to this Association some further description of designs, of methods of construction, of bases of settlements for river diversion damages, now nearing a conclusion by negotiation, and of the experiences in the early years of operation.

A statement of contracts entered into to date, and a tabulation of bids on Contract 8 for the Main Dam and Dike are appended hereto.

The new water supply is being built by a commission known as the Water Supply Board, the members of which are B. Thomas Potter, Chairman, William A Schofield, Henry A. Grimwood, William P. Vaughn, John Kelso, Joseph H. Gainer, and Walter F. Slade. Samuel N. Grammont is Secretary of the Board and the writer is Chief Engineer; William W. Peabody, Frank E. Waterman and Francis B. Marsh, all members of this Association, are respectively Deputy Chief Engineer (in charge also of Dam and Aqueduct Division), Division Engineer (in charge of Reservoir Division) and Designing Engineer. Frederick P. Stearns and Samuel M. Gray were Consulting Engineers up to the time of their deaths, the former in December, 1919, and the latter in November, 1921. Messrs. Allen Hazen and J. Waldo Smith are on the present consulting staff. The writer acknowledges his indebtedness to all of the above mentioned associates and also to many others of the engineering staff, past and present. The valued advice and assistance of Charles T. Main, Consulting Engineer in mill damage cases and of Julius W. Bugbee, City Chemist, are also hereby acknowledged.

# COÖPERATION OF WATER WORKS OPERATORS WITH THE PUBLIC AND EMPLOYEES.

BY F. T. KEMBLE.*

[*September 13, 1922.*]

Following the drought season of 1910 and 1911 there seemed to be an awaking of the interest of the public in the matter of their water supply, with a good sized percentage of them in one way or another getting some posting, more or less accurate, perhaps sometime entirely erroneous, as to where their supply came from and some of the conditions of their service.

Formerly a great mass of people seemed to think that water should be free as air, but that, owing to the Municipality or some man or men having obtained the rights to serve in their territory, a tax was imposed on them. The sound shore district of New York State is a residential section with a population of as high average intelligence as elsewhere; yet numbers of them do not seem to be able to get away from the idea that we tax them and grade the tax according to the size of a house and the number of persons we believe occupy it, using our meters in some way that they do not understand to back up our arguments.

Some of you may recall the late Mayor Gaynor, a few years ago, writing an open letter to the Commissioner of Water Supply of New York City in which he expressed an opinion to the effect that the public should be encouraged to use as much water as they could in their dwellings, that it would be unwise to install meters in the tenements or houses of the poorer persons as they would be apt to use less water for bathing or culinary purposes, certainly they should not be charged by meter and that their tax should be as low as possible.

A certain percentage of those who take issue with us in relation to the amount of their charge, insufficient volume or something else, are really just "trying it on;" hoping that they will be slick enough to somehow or other come out ahead, but probably a majority of those who take up such matters with us don't at all clearly understand the situation. Many are convinced that they are right, that we are in error.

To satisfy our customers when they demand a lowering of their charges or a change in some of our conditions often times requires a lot of patience (if possible a customer should never be just gotten rid of), but the particularly annoying, hard customer to deal with is the party

*Secretary New Rochelle Water Co., New Rochelle, N. Y.

wanting to have pipes extended into the property he is developing; and in almost every case when such a party rows with us, it is a matter of "trying it on," endeavoring to get better conditions than others have.

In my opinion, doing business in as straightforward a manner as possible will later mean the most good to all concerned, — be far more advantageous than having gotten the best of matters at any particular corner.

When one has a set course of procedure, based on years of experience, some of the kicks and demands made seem hard to take seriously. Yet the ones who make them are to remain as customers; and, unless they are very outrageous, it is advisable to try to convince them that the company wishes to satisfy them, wishes to give them the best service possible under the conditions that obtain.

An endeavor to place oneself in the other fellow's position, to find his viewpoint, may be at any time of considerable service,— if in nothing else, in aiding one to disabuse him of some of the prejudice he generally comes in with.

The same idea might be suggested as regards dealings with one's employees, who — be they good, bad or indifferent — are apt to get a deal of ill advice off the job. This applies both to the Italians who at the meetings of their societies on Sunday afternoons, in addition to the listening to newspapers and yarns from back home in Napoli or Calabria, are from time to time harangued by countrymen of theirs who visit in from near by cities; and applies also to the men of more training and value to the plant who have relatives or friends, holding down political or other cinch jobs, who preach to them.

In my opinion what is particularly wanted from employees is "heart in the work;" and the more thorough the understanding between the heads of the force and the various members of same the better the chance for finding this.

I grew up in the service of one of the railroads particularly known for the *esprit de corps* and belongedness-to-the-job of its force. On the line we used to say that intelligence counted and experience counted but what counted most was heart-in-the-work; and my idea of the latter is that it should mean not merely zeal to get on the job but the continuous earnest effort to appreciate and further the requirements of a plant; and I consider efforts made by the force to make satisfied patrons of consumers as a showing that they have the interest of the plant at heart.

We are told a great deal about the inefficiency of men at work, of all classes. "They don't seem to care. We never were so poorly served. They are too old, etc."

Well, I don't know where we ever got 100%, and I'm sure that no matter what the cost or how many gray hairs may be put in the head of the men getting the work done, our plants are growing and we are accomplishing more each year than in "them good old days we hear tell on."

The old type of foreman that would bawl out his men proved not to be the one who could get best results from Dagoes who had been in the Army and had learned to jolly and tease and who were not to be handled the way their fathers had been; and yet some of these younger ones, though only too ready to sit around and look at work going on, can be led to take an interest in their work, to show what pep they've in 'em and so liven up a whole gang.

With both customers and employees, it is up to the Water Company management to get the work through that they are responsible for and the more heart put into their dealings the more thorough will be the accomplishment.

## DISCUSSION.

PRESIDENT BARBOUR This paper of Mr. Kemble's must have touched on some phases of water-works management which will appeal to some of you. It is different from the average paper, and I think it justifies discussion. Mr. Taylor is going to tell you how he organized the gang that we saw yesterday, and deny that they were speeded up for our particular benefit, as some of us were inclined to think.

MR. STEPHEN H. TAYLOR.* That was our regular organization. We have been laying pipe along those lines since July, 1921, and they are pretty well trained. They do that right along when there is trench open to lay the pipe in. There is not always so much trench ahead, but we made an effort to have plenty of trench ready. I think we put in about five while you were there during the half or three-quarters of an hour. That pace can be maintained as long as there is a trench ready. The digging is in rock and hardpan. The program is that the shovel goes ahead and excavates the trench, and the derrick follows behind and lays the pipe in it. As a matter of fact, the derrick lays, in two or three hours in the afternoon, what the shovel digs in a day. The material is loaded into trucks as excavated by the shovel, then hauled and dumped in the back fill. They excavate, lay and back fill anywhere from 75 to 100 ft. every day, with a crew of 12 or 15 men, two machines and a couple of trucks. I think we laid in one day 14 pipes, which was our maximum for one day, excavating, laying and back filling. Work which you saw was not particularly speeded up, except to have a little more trench open, perhaps, than usual.

In some cases, in going through the swamp, we had to go a little slower. It was very soft ground. The banks would cave in, and we would just dig out 12 ft., lay a pipe, and then in digging for the next pipe bring the shovel back and drop the material, taken out in front, into the back fill. The combination proved a very efficient way of handling the job. We have been through some wet swamp and have not had to sheet pile.

* Superintendent Water Works, New Bedford, Mass.

The derrick is also used for a pile-driver. The steam hammer which hangs on the derrick drives the piles. We put on the cap, pick up the pipe, put it in place, go ahead and drive the next pile, and so on.

PRESIDENT BARBOUR. Mr. Taylor, you did not catch my idea exactly. I was not so interested in the detail of what was accomplished as in how you established the morale which apparently was in evidence yesterday.

MR. TAYLOR. It is the result of the training of a year and a half on that same line of work, and the men who are doing that work have been with us for a great many years, and will do anything that we want them to do.

MR. BEEKMAN C. LITTLE.* I wonder if there is any solution of the difficulty that I have, and I think that all must have, of getting younger men to do the digging in the trench and the back filling, the work with pick and shovel. We have a very good lot of men but they are all getting older. They have been with us a good while and are loyal, and are the kind of men Mr. Kemble suggests. We have a great deal of coöperation from them. But have hard work getting new men to come in.

This question was asked the other day by somebody who came to the shop: "Ain't you got no automobile for me to drive?" I said, "No, we ain't got no automobile." They all seem to want either to drive a car or go into an office. There is a great deal of difficulty in getting men to do hard work. We can get men but they are not trustworthy.

MR. CALEB M. SAVILLE.† We have had in Hartford, some difficulty there, as elsewhere, because of mimimum wages for new men but there are younger men that can be obtained.

I am rather inclined to think that the pension system for the older men may offer some solution of this problem. We have, as all of our New England Water Works Departments have, older men who have been in the department a long time. They know the business from A to Z; they know it a great deal better than many other people that can come in and do ordinary work. Those men are exceedingly valuable to us. And more than being valuable in knowing how, they will stay when the younger men, or the newer men, will not. If there is a wet trench, or something breaks in the middle of the night alongside the car tracks, which has to be fixed, those men will stay by and do the work. But they are getting older, and while they can spurt and do more work in a short time than some of the younger men will do, yet for steady, all around work, you have got to have the younger man with his younger muscles.

Now, the older men have gradually been increased in pay as wages have gone up, and many of them have come to the time when they are getting the maximum pay. When you take the younger man, whom you are going to rely on for muscle work, you can't put those men on at first

* Superintendent Water Works, Rochester N. Y.
† Chief Engineer Water Commission, Hartford, Conn.

at the maximum pay, you have to put them on at what you might call your minimum pay. Then you get into trouble right away, because the man who is getting the minimum wage, doing the strong arm work, sees these older men getting quite a bit more money than he is getting, and while he has some enthusiasm in the first place, and would be satisfied if the pay was uniform, it is the pay envelope at the end of the week that counts and makes him dissatisfied with his job.

So that there is something else which must offer a solution to your problem. If there was some pension system that the older men could look forward to it would be a good thing. Not a system that makes a man work forever before he can get a pension, but a system that gives a good, faithful employee really something to look forward to. I believe that something of that kind is bound to come in order to work out this problem, and I believe that in order to be most efficient the pension system must not be a gratuity for old age — charity if you please — but an insurance built up by payments from both the employer and the employees. In this way you approach the desirable ends; loyalty to service is created by personal interest in growth of the personal fund, and an investment available when the time of maximum abilities for service has passed.

Mr. J. M. Diven.* Some superintendents who manage municipal plants do not always have the choice of the men they will hire. If the superintendent gets out with his men once in awhile, gets down into the trench to see what is going on, makes himself more or less one of them, he may get better coöperation. I believe the superintendent who can't get the good will and loyalty, and even a little of the love of the man he works with, is going to make a failure.

Mr. Patrick Gear.† I do not know that Mr. Saville is familiar with the pension system we have here in Massachusetts. I know of a man who has been seventeen years a laborer, and has been a foreman now for two years, and when he is sixty-five he can retire at $400 a year as a foreman. If he had stayed a laborer he would retire at half pay, which would give him about $800 a year.

Mr. Saville. I said a good pension.

Mr. Gear. Now, it is more advantageous for a man to stay as a laborer than to go on as a foreman to-day. Then if he goes from that on up to be superintendent he doesn't get anything. The laborer has the advantage if he only knew it. Then you get the young class of men that Mr. Kemble speaks of, who are of the sporting type, and they are not reliable.

Mr. Henry V. Macksey.‡ I cannot agree that we wouldma terially help our present difficulty by the pension system. The cause of the trouble is that most of the young men whom we might expect to become laborers are American born, and educated. They are filled with an ambition to

* Secretary American Water Works Association.
† Superintendent Water Works, Holyoke, Mass.
‡ Superintendent of Public Works, Framingham, Mass.

be something better than laborers. We should be in sympathy with them. When a young man comes to me, an American born citizen, and wants a job as a laborer, unless he is in hard luck and really needs work and money at once, I try to find out what other line he is fitted for and to help him to properly place himself, rather than retain him as a laborer. I think that I am doing the right thing, for that man will never be a good laborer because his heart can not be in his work.

We all know that we have depended for years for crude labor on importations. The Irishmen of former days were the best laborers in the world; we can get no more of them, and our best bet is the Italian. The Italian is not yet assimilated. He does not think he is one of us. He does not take the interest in municipal affairs that the Irishman does.

Now, the real difficulty, it seems to me, is this: we do not have all year around work for all of our men. If we have a pension system we must keep the men regularly employed. With water supply work in this climate, of course we expect to carry a much larger gang in the summer than in the winter. In the winter our work is principally emergency work. The average city or town is not willing to do outdoor work in the winter, which costs 25 or 30 per cent. more than it would if done in the summer, just to keep an organization together. You can't keep a complete organization all the year round under our present way of managing municipal works. In our little town to-day we pay five cents per hour more than contractors are paying around us, but men do not come to us for work. The story told all over this part of the country to-day is that there is no idle labor.

MR. SAVILLE. I think I shall have to take exception to what my friend has just said. We have little idle labor in Hartford, and we can get all the labor that we need at reasonable prices.

We keep a rather large force all the year around in order to have an efficient gang. We have large forestry areas and they work in these during the winter. This increases somewhat in the summer.

MR. KEMBLE. I have made a big effort in recent years to keep the men we have and get such men as we could. I have not been quite as altruistic as my friend, about men being better fitted for something else. I have tried to find work for them, wet or dry, and we have worked our gangs right through the winter. In bad weather we have tried to find work around the yards. The older men who are on the job will stay. They would be unhappy elsewhere. The younger Italians come and go. They won't stay with you as soon as they can get more money elsewhere, but will leave you in the lurch.

MR. RICHARD H. ELLIS.* It seems to me that in the small municipal system, a great many times we should meet conditions as existing in our neighboring industries. In other words, it is a case altogether of supply and demand. A good many times the municipality sets a wage over which the official in charge of the work has no option in granting a little more

* Superintendent Board of Public Works, North Andover, Mass.

money or a little less money, and consquently we have to put up with the type of labor that is willing to accept a low wage. The solution seems to be to pay a little bit more money, where we cannot hold our employees the year around, so as to get the best labor available. The pay envelope if it is large enough is sufficient incentive to get a man's best efforts.

MR. HENRY T. GIDLEY.* We have tried to make a practice of keeping a small gang employed most of the year round rather than a very large gang, but of course have more in the summer, but try to spread the work out throughout the year. We are a private company.

In the matter of pay, we confer with the Street Department to find out what they are going to pay, and pay about the same wage, so that the men are not dissatisfied and moving from one department to another. I think that idea of a small gang and keeping them employed, if you can do so, is rather better than to have a large force in the summer and discharging them all in the winter.

MR. GEORGE F. MERRILL.† I think Mr. Taylor's work is a good example of what the use of machinery will do in keeping the size of your gang down. I have found that in laying pipe with a trenching machine you can do with ten or a dozen men as much as could ordinarily be done with 40 or 50 under usual methods of hand labor. It gives a chance to employ a smaller gang, which can be kept employed throughout the year. And it keeps a better class of men.

MR. TAYLOR. One of the main reasons we got the shovel was because of that big job of 36-in. pipe (about 6 600 ft.), on the boulevard, and there was a shortage of labor at that time. So we got the shovel to overcome that difficulty, but found it such a labor saver that we kept on with it when men were plenty.

Last winter when the ground froze up so that it was rather expensive to do that work, we put the crew in the woods on forestry work. Those who have forest work to do can utilize their regular gang in the winter, and that is the time of year when you can burn up your rubbish and do a lot of trimming and cutting out of dead wood. We keep practically all that gang the year around, besides other men down town for service work, and the emergency crew. I think our pay-rolls in the winter carry perhaps 40 or 50 of what might be called the laboring force, between the forestry work and the emergency crew. We also utilize our emergency crew in the winter in making up gate boxes, concrete forms, and all sorts of things for the next year's work. Our crew does not vary so much except when we get a big rush of small main pipe work, short lines, where it does not pay to send a shovel. When we get a rush of that we have to increase our crew.

In New Bedford the Portuguese prove about as good laborers as we can get, — better than the Italians. They seem to have a little more intelligence and more ambition to get ahead.

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*Superintendent Water Works, Fairhaven, Mass.
†Superintendent Water Works, Greenfield, Mass.

# DESCRIPTION OF NEW BEDFORD WATER SYSTEM.

BY STEPHEN H. TAYLOR.*

[*September 12, 1922.*]

On March 6, 1860, an order was passed by the City Council, calling for a committee "to consider the practicability and expediency of introducing a permanent supply of fresh water into the City and report some plan with the probable cost of doing so," etc. As a result of the studies of this and successive committees, an act authorizing the supplying of the City of New Bedford with pure water, was passed by the State Legislature April 18, 1863, and after three years' of study the first real effective water system in New Bedford was started in 1866. It was completed in 1869. A dam was built across the valley of the Acushnet River in the Town of Acushnet seven miles north of the center of the city. This created an impounding reservoir of 300 acres, at 40 ft. elevation above M. H. W., supplied by a water shed of about three to four thousand acres.

From this reservoir an egg-shaped brick conduit 4 ft. high by 3 ft. wide was constructed to bring the water to a receiving reservoir of three million gallons capacity, at an elevation of 30 ft., located in what was then the outskirts of the city. From here the water was pumped 1 879 ft. west through a 16-in. cast-iron force main to the Mt. Pleasant distributing reservoir, the capacity of which is fifteen million gallons, at elevation 154 ft., thence by gravity to the distributing system.

The original pumping engine was a five million gallon McAlpine, cross compound, of the walking beam type. This was later augmented by a three million gallon Worthington, and still later by a five million gallon Worthington, with the necessary boilers in each instance.

The population of the city was then about 20 000, and the distributing system consisted of 17 miles of main — some cast-iron but mostly wrought iron, cement lined, from 4 to 12 in. in diameter; and 553 services mostly of lead. The average consumption of water for the first year was 329 375 gal. per day.

In 1886 the consumption had increased to an average of 3 000 000 gal. per day. As this was beyond the safe capacity of the original impounding reservoir, a connection was made to Little Quittacas Pond by means of an open ditch 1½ miles long, following in part an existing stream.

In 1893, 5 000 000 gal. per day was being used. That was about the safe limit of the system, and besides this, building activities were extending into the higher parts of the city, some of which were above the level of the reservoir.

*Superintendent Water Works, New Bedford, Mass.

Messrs. George S. Rice and George E. Evans, Engineers, were employed to make a thorough study of the situation and recommend the best means of obtaining an increased supply at greater pressure. Their work was done in conjunction with Mr. R. C. P. Coggeshall, Superintendent, and as a result of their combined efforts the present system was built. It has been in service since 1899, with the old Acushnet System held in reserve, the old distributing reservoir being connected by a check valve.

The right was obtained from the Legislature to take water from Little and Great Quittacas Ponds, located in Rochester, Lakeville and Middleboro, about twelve miles north of the city, with ample powers to construct and maintain the system. It also authorized acquiring such lands as were necessary for this purpose by purchase or condemnation.

A dam was built between Great Quittacas and Pocksha Ponds with suitable waterways for the discharge or overflow of the surplus waters from Great Quittacas into Pocksha, but preventing water from flowing back from Pocksha to Great Quittacas Pond.

A six foot masonry conduit connects Great and Little Quittacas Ponds, the flow through which is regulated by a sluice gate.

The storage capacity of Great Quittacas Pond is 4 500 000 000 gal.; the area of the pond is $1\frac{3}{4}$ sq. mi., and its water shed is $9\frac{3}{4}$ sq. mi. Little Quittacas has a storage capacity of 1 000 000 000 gal.; area of pond is about $\frac{1}{2}$ sq. mi. and water shed a little less than 1 sq. mi. The elevation of these ponds is 50 ft. above sea level.

No filtration or chemical treatment has been found necessary, as the entire shore of both ponds and a part of their tributaries is owned by the city. There are very few buildings on these shores. They are kept free from pollution and almost entirely covered with a good growth of wood.

It is a very gratifying fact that although all cases of typhoid or other water borne diseases are carefully traced, none has ever been traced to the city's water supply.

The city now owns about 2 000 acres of land on the water shed and is buying more as the opportunity offers. A great deal of forestry work has been and is being carried on there. Most of the hard woods have been cut off and many thousand white, red and Scotch pines have been planted, as well as some firs and hemlocks.

A scheme is now under consideration which, if carried out, will place the remaining Lakeville Ponds in the control of a joint commission for the use of all the cities and towns of Southeastern Massachusetts.

The combined area of the entire group of ponds is about 9 sq. mi., and the total water shed 38 sq. mi.

The pumping station is located on the southerly shore of Little Quittacas Pond. The pump well in the pumping station is connected by a six foot masonry intake, on the outer end of which is an eight mesh revolving screen.

The pumping equipment consists of two ten-million-gallon, steam driven, compound beam and fly wheel engines, designed by E. D. Leavitt and built by the Dickson Manufacturing Co. of Scranton, Pa., each operating two differential plunger pumps.

Steam is furnished by two 150 h. p. boilers of the Scotch Marine type, also designed by Mr. Leavitt. No extensive repairs have ever been necessary on this plant. It is still in excellent condition and is running twenty-four hours a day, showing an average duty of 130 000 000 ft. lbs. figured on total fuel used for all purposes.

A six million gallon DeLaval centrifugal pump driven by a G. E. squirrel cage, type I, 3 phase, 60 cycle, 550 volt, 250 h.p. induction A. C. motor was installed in 1918. This is a convenient auxiliary though less economical than the steam pumps, and can be operated without any additional attendants.

The water is pumped through a steel force main eight miles long to High Hill Reservoir. This pipe was laid across country in a strip of land 5 rds. wide, which was purchased by the City. From Braley's Station, on the N.Y.N.H. & H. R.R. to the Pumping Station, it is paralleled by a standard gage railroad. The road was built early in the construction of the system and was a very important feature in the transportation of the materials for building and equipping the Pumping Station and force main. It is used now for the transportation of coal and heavy supplies to the Pumping Station. All of the 6 600 tons of pipe for the new 48-in. cast-iron force main were delivered over this road. The main is of $\frac{5}{16}$-in. riveted steel with lap joints and coated inside and out with asphalt.

Great care was taken when laying it to patch the coating where broken in transit or in laying. Frequent tests for leakage are made and careful internal inspections have been made from time to time. Last year a piece was cut out for the purpose of making a 36-in. connection to the new 48-in. cast-iron now being laid. This piece may be seen at the Water Works Office in the Municipal Building.

The results of all these examinations seem to show that while there is considerable pitting, the pipe is still good for several years service.

A new 48-in. cast-iron main is now being laid which will make it possible to pump directly to the distributing system, in case of trouble with the steel main, using the reservoir as a balance. This cast-iron main will eventually be carried to High Hill Reservoir; we hope, before the steel main fails.

A wrought iron standpipe 20 ft. diameter by 75 ft. high has been erected and is connected with the new pumping main at the summit, which is also the highest point in the city. The connection to the main was made by using a tangent branch with the outlet arm at the top of the pipe. This is intended principally for an air vent and surge tank. The reservoir pressure fills the standpipe about half way, the remainder of the height allowing for the surge when pumping directly to the city.

High Hill Reservoir is located five miles northwest of the center of the city, in the Town of Dartmouth. When full the water stands at elevation 216 giving from 14 to 90 lb. pressure on the system. The average pressure in the business district and where the hotel is located is 65 lb. The reservoir is 1 000 ft. x 500 ft. x 20 ft. deep, and is divided by a masonry wall across the middle into two sections 500 ft. square. Its total capacity is 68 000 000 gal. The inlet and outlet gate houses are so arranged that either half may be emptied for cleaning or repairs and the other half kept in service. The piping is so arranged that the reservoir may be by-passed and water pumped directly into the distributing mains if desired.

The reservoir was built by excavating part of the top of the hill and building up the embankment in layers with a stone retaining wall from elevation 207 to 218; elevation 216 being H.W. The bottom and sides from elevation 196 to 11 are covered with a 9-in. layer of concrete. They have a slope of 2 to 1. The top of the bank is at elevation 220, and the outside slope is 2 to 1, and is covered with a good growth of grass from which quite a crop of hay is harvested each year. No leakage from the reservoir has ever occurred and aside from occasionally pointing up the stone walls at the water level, and a few very small cracks in the concrete slopes, no repairs have been necessary.

Two 36-in. cast-iron mains run parallel to each other from the High Hill Reservoir to the northwest part of the city from which point they form a loop of 36-in. and 30-in. pipe around the city. The entire distributing system is gridironed with a goodly percentage of large pipes as will be seen by the following statement of sizes:

| | | |
|---|---|---|
| 48-in. 5.1 per cent. | 36-in. 6.9 per cent. | 30-in. 4.2 per cent. |
| 24-in. 1 per cent. | 20-in. 1.2 per cent. | 16-in. 5 per cent. |
| 12-in. 5.6 per cent. | 10-in. 7.6 per cent. | 8-in. 21.4 per cent. |
| 6-in. 37.6 per cent. | 4-in. 4.4 per cent. | |

This does not include the 12 000 ft. of 48-in. cast-iron pipe being laid this year.

We are quite proud of the fact that this system is charged with only thirty-one of the possible seventeen hundred points of defect in the latest report of the National Board of Fire Underwriters. Fifteen of these are because of the pressure in the high value mercantile district being sixty-five instead of their standard eighty pounds. New Bedford is now in the second class in the National Board schedule of ratings.

Our mileage of main pipe, 4-in. and over, at the beginning of the year was 185¾ not including hydrant branches and blow-off connections. The system is cut into moderate sized sections by 2 545 gates. There are 1 650 public and 447 private fire hydrants. The number of services is 16 354, all the active ones being metered except private fire supplies.

Water is also supplied to the towns of Dartmouth and Acushnet

through meters located at the Town Line, as well as a few houses in Freetown and Lakeville.

The average daily consumption last year was about 9 500 000 gal. or 71 gal. per capita. Manufacturing meters account for 41 per cent., domestic and commercial meters for 40 per cent., leaving 19 per cent. for fires, flushing and all unmetered uses and leakage.

Water is sold for manufacturing purposes at 10c. per thousand gallons and for all other purposes at 15c. per thousand. Public buildings, parks and cemeteries are charged the same as private owners, but no income is derived from fire hydrants or private fire supplies. The annual revenue of the department is sufficient to cover all maintenance and repairs including payment of bonds, sinking fund and interest, and provides for a moderate expenditure for extensions each year.

The total cost of the works to December 1, 1921, was $4 676 910.93, and the net debt was $482 755.97. Both figures are exclusive of the $700 000 bond issue for the new 48-in. cast-iron force main now under construction.

Since the beginning of the works the total receipts for water have been $7 273 084.85 of which $1 826 662.79 have been applied to construction. All ordinary extensions including the 48-in. main now under construction are made by the department.

In 1920 the department had about 6 600 ft. 36-in. main to lay in addition to the ordinary extensions, and as labor was scarce, it was decided to purchase a 14B Bucyrus Steam Shovel with an extended dipper arm for trenching, and in 1921 when the 48-in. main was started a 14B Bucyrus "Clamshell" and derrick machine with a 30-ft. boom was purchased. These machines have proved great money savers on the large pipe work which has been done in the past three years. The latter machine is used for pipe laying, and in places where the ground is too soft to support the steam shovel over the trench, excavating is done with the clamshell outfit on the same machine. Under ordinary conditions the excavation is done by the steam shovel travelling on platforms over the trench with the derrick following close behind, laying the pipe. The shovel deposits the excavated material into trucks which haul it directly to the backfill close behind, or to the spoil bank.

With reasonably good conditions, from 120 to 180 ft. of trenching, pipe-laying and backfilling per day is accomplished with a crew of from 15 to 20 men, two or three trucks, and the steam shovel and derrick. The advantage of a small crew is particularly great in our present work, which is ten to twelve miles from the city, and as there is very little local labor available the men must either be boarded near, or transported to and from the job.

A convenient and well equipped work shop and pipe yard are maintained near the center of the city, with an emergency crew and gate operating truck always available to handle breaks or other sudden calls.

## Experiments with Substitutes for Lead for Jointing Cast-Iron Pipe.

Until within a comparatively few years Water Works engineers have been pretty unanimously of the opinion that the best if not the only satisfactory material for jointing cast-iron bell and spigot pipe was a good grade of soft pig lead, well caulked. As you all know, it was applied by pouring the melted lead and then driving it firmly into the joints with caulking tools.

During the past fifteen or twenty years various substitutes have been placed on the market and widely advertised throughout the Water Works field. The principle advantages claimed for these substitutes was the great saving of expense for both material and labor.

The writer, like all good conservative Water Works officials, has hesitated to change from the established custom of using lead.

Some ten years ago a few joints in the smaller sized pipe were made in the New Bedford Water system with two of the substitutes,— Leadite and Lead-Hydro-Tite, and no trouble has ever been experienced from either.

In the Spring of 1920, the writer decided to make some more extensive experiments with them. The City of New Bedford was then contemplating the laying of about 6 600 ft. of 36-in. pipe in addition to the usual yearly work, and as prices of everything were extremely high, any saving that could be made without decreasing the efficiency of the work was worth considering.

At that time Leadite was offered at 12c. per pound and Lead-Hydro-Tite at 10c. while lead was selling for about 7½c. per pound. One pound of either substitute would fill as much joint space as four pounds of lead, so that it would take 30c. worth of lead to do the same work as 10c. worth of Hydro-Tite or 12c. worth of Leadite. There is also a further saving in the reduced labor cost, because no caulking is necessary, and the size of bell holes is greatly reduced. The only chance for skepticism, then, was as to their efficiency. As the contemplated work involved a considerable amount of jointing material, the two cents per pound difference in cost of Leadite and Hydro-Tite, was worth saving if the two materials were equally efficient. The experiments here described were made to determine this point as well as to determine their ability to stand high pressure, and the elasticity of the materials.

The experiments were made with the assistance of Mr. W. R. Conard, Engineer, Mr. Hays R. Kuhn, at that time employed by the Pennsylvania Water Co., who was familiar with handling Leadite, and Mr. Jacob Handy, Superintendent of Dartmouth Water Works, who had considerable experience with Lead-Hydro-Tite. Mr. George McKay of the Leadite Company and several Water Works officials from nearby cities and towns were also present.

*Experiment No. 1.* Six lengths of 6-in. pipe were put together on skids about two feet high in the pipe yard of the New Bedford Water Works, with a plug and sleeve on one end made up with lead and a patented plug in the other. Three joints were made of Leadite and three of Hydro-Tite. Dry white jute was used in their different forms. One joint with each material being made with loose yarn, one with the same yarn twisted lightly, and a third with the same yarn braided; similar in appearance to packing, but without oil or grease.

The pipes were first filled at city pressure (84 lb.) and the joints were all reasonably tight, the greatest leak occurring at the joint made of Leadite with loose yarn.

There were also some leak at the joint made of Hydro-Tite with twisted yarn. The pressure was then raised, first to 150 lb. and then to 200 lb., all joints remaining reasonably tight and becoming entirely so with the exception of the two above mentioned. The high pressure was then released and normal yard pressure (84 lb.) maintained during the remainder of the test.

The ends of the pipe were raised by means of a derrick at each end, the supports, which were under the pipe, being removed as the pipes were lifted from them until, for a short time, the line was practically suspended by the ends, forming a curve with about 144 ft. radius and the ends 5 ft. 9 in. higher than the center.

Finally joint No. 5 of Hydro-Tite broke, allowing the center of the line to drop to the ground. It should be said, in fairness, that the joint which failed was not made with a continuous pouring, because some of the material was lost through a defective dam and a second pouring was necessary. Only a few seconds elapsed between the first and second pouring, however, as the kettle was close to the joint and it was only necessary to dip out more material.

The whole line was then lowered to the ground and remained tight except the two joints before mentioned (No. 2 and No. 5). These were made tight by caulking with a little lead wool, and for several months the line remained in the yard in asbolutely tight condition, in spite of the abuse to which it had been subjected.

*Experiment No. 2.* As the principal work of the year was to be 36-in. pipe, it was thought advisable to experiment with this larger size to see if it could be successfully poured. Two lengths of 36-in. pipe were joined, with a plug in one bell and a sleeve and plug on the spigot end. Accidentally a class B pipe N.E.W.W. Assoc. specifications was placed into a class F bell. This made an unduly thick joint (about $\frac{7}{8}$-in.). The class B bell was too small to receive the beaded end of the plug, so the plug was reversed. This made an abnormally thin joint with no bead, as the space was so small that it would have been impossible to caulk a lead joint. These joints were made with Leadite. On the other end the sleeve and plug were normal $\frac{1}{2}$-in. joints and poured with lead Hydro-Tite.

When the yard pressure was applied, in spite of the bracing at the ends, the joint between the two pipes slipped about ¾-in. This was the abnormally thick joint. The 84 lb. yard pressure on the 36-in. plugs develop a total stress on each of them of about 42½ tons.

The braces were then removed and the pressure applied with the intention of pulling the work apart. When this was done the two abnormal joints made with Leadite held fast, and the one where the sleeve joined the pipe which was a normal ½-in. joint made with Hydro-Tite pulled apart.

As a result of these tests, it was decided to adopt Leadite for our work, and it has been used in practically all the joints made since that time with excellent results.

The story of this test would not be complete without further reference to the advantage of the braided jute packing, which we have also adopted for general use. We find that although it costs a little over twice as much per pound as the plain dry jute, the saving effected in labor and material more than offset the extra cost, and that a better joint is obtained because there are no loose ends of the fiber to mix with the jointing material and reduce its efficiency.

Since writing the above, a very favorable opportunity was presented for comparing the cost of 48-in. joints made of lead and Leadite, as two joints were made of lead on the check valves of our 48-in. line, because of the extreme weight of the casting and uncertainty of the ground in which it was placed.

Figuring the cost of jute packing, labor and lead, a 48-in. joint cost $18.06; whereas the same items on Leadite joint cost an average of $4.42. It took three men one hour and forty minutes to pour and caulk a lead joint, whereas the same three men would average to pour from six to eight joints per hour with Leadite.

## Discussion.

Mr. William W. Brush.* How long was your high service reservoir in use before you cleaned it? If I recall correctly, you said you had 6 in. of deposit.

Mr. Taylor. There was about 6 in. of deposit. That was the result of about fourteen years of service since it had been cleaned. It was very light material.

Mr. Brush. In what way does that deposit cause you any difficulty?

Mr. Taylor. It did not cause us any difficulty, but thought as a matter of protection and cleanliness we had better clean it out.

Mr. Brush. Did you find any difference after you had cleaned it in the quality of the water over what it had been before you cleaned it?

* Deputy Chief Engineer Bureau of Water Supply, New York.

MR. TAYLOR. I would not say there was very much difference. Our outlet is raised up a little from the bottom so that it did not get that sediment. I suppose there would come a time when the sediment would get to the bottom of the outlet and then it would be drawn into the mains.

MR. BRUSH. There was no difference in the microscopic growth, or anything of that kind?

MR. TAYLOR. No. I should say it was a vegetable deposit. The water, of course, travelled across the reservoir, and in the earlier days it travelled much more slowly, because the capacity of the reservoir is 68 million gal., and when the reservoir was built our consumption was 5 000 000 a day, so that the rate across was slow and it had lots of time to settle. Now it goes across faster because our rate of consumption has doubled. We use now 10 000 000 or 10 500 000 gal. a day.

MR. J. M. DIVEN.* What trees do you plant on your watershed, Mr. Taylor?

MR. TAYLOR. We have planted mostly pines, starting with the white pine, supposing they had about as few enemies as any other tree. Then came the white pine borer. We are now planting, as fast as we can get them, red and Scotch pine. We have not yet found the enemies of the red pine and Scotch pine and are using them at present, although it is very difficult to get enough of them. Last year I had to take about half of the white pine and the other half red and Scotch.

MR. DIVEN. In New York they have given up the white pine entirely.

MR. TAYLOR. It is only within a few years we have had trouble with the white pine. We are cutting off the hardwoods as fast as possible on account of the gypsy moth. I would like to find a tree somewhere that has no enemy to destroy it; I have taken up the question with our State Forestry Department and gotten the best advice available.

A MEMBER. What age pine do you plant?

MR. TAYLOR. We have raised some from our own seeds, but usually get about three or four year transplants. We sometimes transplant a large section from our own reservation from one place to another. When buying we buy three and four year seedlings.

MR. DIVEN. How are you taxed on your property outside of the city?

MR. TAYLOR. That was fixed by the Legislature in our Act of 1914. The average valuation for the three years previous to the time we bought it becomes a fixed valuation for all time, Valuation can be neither raised nor lowered. Of course the assessments rise and fall with the tax rate, but the valuation remains the average of the three previous years.

MR. DIVEN. They do not tax you on your improvements?

MR. TAYLOR. No.

MR. DIVEN. You get out better than we do in New York.

MR. TAYLOR. They get us a little bit outside of our watershed. We have two houses for our engineers to live in, and they tax us there to make up on what they lose on the watershed.

*Secretary American Water Works Association.

MR. DIVEN. Are you taxed the full cost value of the pipe lines in the ground?

MR. DIVEN. No; we pay the city on the same valuation made for the three previous years, without any tax on the mains.

MR. DIVEN. That is a fair and equitable tax.

MR. TAYLOR. I think so. Where we go through a town we sometimes furnish them with water. In Freetown, where our new main is laid, if they want water we serve them at the same price that we do in New Bedford. That, of course, benefits the town a little.

MR. GEORGE W. BATCHELDER.* Did you have to get special legislation to furnish water in Freetown?

MR. TAYLOR. Yes. And it is the same in any other town. It is the same with Dartmouth and Acushnet.

MR. J. A. RAINVILLE.† Is there anyone here who has had experience with cement pipe?

MR. TAYLOR. Our experience with it is of old times. When the system was first built, I should say perhaps more than half of it was cement lined pipe, but it got pretty weak and before we put on the increased pressure due to our new system we got it all out and replaced it with cast-iron. Several breaks occurred in it from time to time. I think other cities are using it more sucessfully.

MR. FREDERIC I. WINSLOW.‡ How much trouble did you have in getting your men to use Leadite properly?

MR. TAYLOR. None at all. We had a man come here who had been familiar with using it a number of years. We put a green man on who was a fairly intelligent laborer, and after seeing one or two joints made he did it himself. There was no difficulty in instructing a man of the ordinary laborer's intelligence. Of course you would not take the greenest sort of man, but one of your ordinary laborers can learn to use it in a short time.

MR. BRUSH. Do you use Leadite here in the city?

MR. TAYLOR. Yes; we are using Leadite almost entirely. As the result of our test we felt that for our particular purposes Leadite was what we wanted. It seemed to hold up, in my opinion, a little stronger than the other. I think, as a matter of fact, for ordinary light work, there would not be a great deal of difference between the two. But the test we made seemed to show to me, and all who were present at the test, that the Leadite was a little stronger for all around work.

MR. BRUSH. Have you had any mains break where you have used the Leadite?

MR. TAYLOR. No. We have not had the slightest trouble from any cause. I do not know of a joint that we have even had to dig up, and we have put in, in the last few years, about ten miles in our regular distributing system, and about three and a half or four miles in our large 36

* Water Commissioner, Worcester, Mass.
† Foreman Crystal Water Co., Danielson, Conn.
‡ Division Engineer Metropolitan District Commission.

and 48-in. mains. There are very few joints in New Bedford which have been tested before turning the water on. We were so confident that the pipes are now covered before filling. Once in awhile we have uncovered a joint, thinking it a joint leak, but it proved to be surface water, or something else. So that our experience with Leadite has been very satisfactory.

MR. A. O. DOANE.* I think it would be interesting if you would explain the difference in the jute, as you did this morning.

MR. TAYLOR. Either one of these joint materials requires white, clean jute. We are using a braided jute. There is a sample of it in Mr. McKay's exhibit. It costs about double the cost of unbraided, per pound: but it saves, I think, more than that in labor and wastage. There is no wastage from the braided jute, which is cut just the right length, and braided good and hard. A man tamps it in all around, and you do not have to drive it with a hammer. There also is an advantage in a joint of that sort in not having any loose ends running out to destroy the joint. We feel, even thought we pay twice as much for it, that better results are obtained by using the braided jute. It is the same grade of dry jute as the unbraided.

MR. A. B. COULTERS.† What pressure was maintained on the pipe in your yard during the flexure test?

MR. TAYLOR. Eighty-four pounds. I might say, we had a caulker who was some caulker, and that after the joints broke down he drove some lead wool into the broken joint, and the line lay in the open yard for months, absolutely tight with the pressure on.

MR. FRANK A. MARSTON.‡ In the northern part of New York State, there are a number of miles of 6 and 8-in. pipe, in a system for a spring water supply, which were laid with Leadite, and it was found by test that the leakage from Leadite joints was not much greater than from lead joints, after letting the joints stand for about a week. At first the joints would drip a little and at that time would fail to pass the test limiting the allowable leakage to two gallons per linear foot of pipe joint for twenty-four hours, but after standing for a few days, or a week, the leakage would be reduced to acceptable limits unless there was an imperfectly formed joint.

One section of pipe which was laid in about a 6-ft. trench was exposed during the middle of the day to the sun, while during the remainder of the day it was shaded. In the morning and at night the joint would be tight, but in the middle of the day when the sun rose so that it shone on the pipe and warmed it up there would be enough expansion so that the joint would begin to drip a little.

As far as laborers are concerned, my observation has been that it is just as well to start with a green man rather than to take an experienced

* Division Engineer Metropolitan District Commission.
† Of Builders Iron Foundry, Providence, R. I.
‡ Of Metcalf & Eddy, Boston, Mass.

lead melter, to avoid prejudiced ideas as to how the compound should be melted. The jointing operations are very simple, and an intelligent laborer can readily learn to make good joints after a few days instructions.

Our experience has shown these two compounds, Leadite and Lead-Hydro-Tite, to be satisfactory where the conditions permit of their use.

MR. FRANKLIN HENSHAW.* The difficulty we had with one man, who had previously been an expert in handling lead, was his insistence on making a low gate, and you cannot get a good Leadite joint unless the gate is amply high. Another difficulty was with the jute packing. Where the braided jute was used we did not have a bit of trouble, but in one case they ran out of that and tried to make a joint with unbraided jute, and did not get the fibres on that jute all packed into the back of the bell, a few would stick out, and in every case where that happened there would be a drip. It would be found in the course of time, but it made a great deal of trouble at first. Consequently, the braided jute was ordered and used entirely after that.

MR. HENRY T. GIDLEY.† I would like to say that we have used almost entirely for three years the Lead-Hydro-Tite with very good success.

I think some of the former speakers were right when they said that they do not want to take a man who has melted lead to use on the Hydro-Tite, for the Lead-Hydro-Tite does not require so great heat as the lead, and they are apt to burn it up at first, because you can get it too hot easier than you can just the right temperature.

The bending qualities of Lead-Hydro-Tite we have tested where we had to lower our pipe, and in one case we lowered 72 ft. of 6-in. pipe 2 ft. with the water pressure on and no leaky joints. In another case, where the grade was changed in a street, where there was a cross street and we had to lower the pipe, we lowered it 2 ft. in 100, and the cross T was lowered a foot, and beyond the cross T the pipe was lowered until it started to buckle a little, but no joint in the pipe showed the least sign of leaking. This was over a little rise, so that the pipe as lowered was really shortened rather than lengthened.

MR. TAYLOR. I may call your attention, Mr. President, to the last sentence of this little paper of mine, — " Figuring the cost of jute packing, labor and lead." There was an opportunity to make a pretty accurate comparison. We made two joints on a very heavy check valve, which was in a soft bottom, with lead, with the idea it might need to be recaulked at some time or another. The average of those two lead joints was $18.06. That is simply the packing, labor and lead. While the same items in the Leadite joint cost an average of $4.42 per joint. That makes no allowance for the very great difference in the depth in digging and maintaining bell holes in wet trenches.

MR. W. C. HAWLEY.‡ We have recently completed a line of 8-in. pipe, but on account of delay in getting a right of way we had an oppor-

* Superintendent Water Works, Scarsdale, N. Y.
† Suprintendent Water Works, Fairhaven, Mass.
‡ Chief Engineer and Manager Pennsylvania Water Co.

tunity to test about a mile of it before it was put into service. After a day or two we found that the leakage was so little that it would not register on the best $\frac{5}{8}$-in. meter that we could pick out. I do not know just what that is in cubic feet per hour, but you can see that the leakage was very small.

We usually test our pipes in the open trench. Perhaps it is not necessary, but we believe that it gives us a little closer check on the man who is making the joints, because if we find a joint that shows any considerable leakage, anything more than mere seepage, we know there is something wrong in the way that joint was poured, and it gives us an immediate check on the man who poured it.

I want to take this opportunity, by the way, to correct a statement that was made in the last JOURNAL, to the effect that I was the first one to use Leadite in Atlantic City. That is not correct. Mr. Kenneth Allen, my successor, used Leadite there, I think in 1903 or 1904. I did not use it until a year or two later at Wilkinsburg.

PRESIDENT BARBOUR. Mr. Marston, I believe you referred to the use of Leadite in a suction system from springs. Does that mean it was under a vacuum suction system?

MR. MARSTON. No; it was a gravity system.

PRESIDENT BARBOUR. Has anyone ever used Leadite where the pipe was under a partial vacuum? (No response.)

MR. PATRICK GEAR.* I would like to know if any of those gentlemen who use Leadite would take a chance under a railroad track, where you have to cover it up before testing.

MR. TAYLOR. We would be perfectly satisfied to go ahead and use Leadite. We always cover our pipe as soon as laid, without waiting for a test, we are so confident of it. We never yet have had a failure, and sometimes it is under quite a strain.

MR. HAWLEY. If the pipe is laid by a man who knows how to lay it, that is the place for Leadite.

MR. MARSTON. In a pumping station where pipe is subject to vibration, Leadite has been used up to 12-in. pipe, and they have stood up very nicely.

PRESIDENT BARBOUR. I think I am stating the fact in saying that Mr. McInnes has used Leadite in the crossing over the Neponset bridge where there is very pronounced vibration, and has used it in preference to lead at that point.

MR. ALEXANDER ORR.† Has anyone used Leadite or other substitutes for lead in any of the exceptionally cold cities where we have to do considerable thawing by electricity?

MR. GEORGE MCKAY, JR.‡ Mr. Bugbee of Trenton, N. J., in the very cold winter of 1917, had 2 000 services frozen, and used electricity

* Superintendent Water Works, Holyoke, Mass.
† Superintendent Water Works, Gloversville, N. Y.
‡ Of the Leadite Co.

in thawing. They never had any difficulty in putting the current through. I think the main thing is to keep the voltage low and get the amperage up to about 250. Do not get the voltage too high.

MR. ORR. Are those laid in the regular manner?

MR. MCKAY. Laid in the regular manner.

MR. DOANE. Is there testimony to be offered as to the effect of electrolysis on the water pipes containing these compounds?

MR. HAWLEY. I can say that the Leadite materially decreases the amount of current flowing through our mains.

MR. BRUSH. From your experience would you consider there would be any serious difficulty in running water mains where your mains would be laid by a contractor who received a contract as a result of being a low bidder, where there would be no testing of the mains although the contractor would be held responsible for a year for any leakage that developed?

MR. TAYLOR. If I was having work done by contract I should certainly want to see it under pressure before it was covered. We do all of our own work here, that is why we cover it up. We have men who are very familiar with it, and we feel confident. But if it is going to be done by contract I would want to see it under pressure before it was covered, by all means.

MR. DIVEN. I might add one thing to that, Mr. Taylor, and say, whether it is going to be done by contract or not.

MR. JOSEPH A. HOY.* In making water-works caps, do you use Leadite, or lead?

MR. TAYLOR. We usually use Leadite. When we had a big cross connection, a 36-in. or a 48-in. steel main, we put the responsibility up to the Water Works Equipment Company. They made the joints with lead, and filled in the space between the joints with cement grout. But we have used Leadite in many cases, and with good success, on our own work.

MR. DIVEN. I would state for the information of the gentleman that I made, on a 30-in., with the water on, a Leadite joint for two 8-in. outlets, tapping the sleeve through two 8-in. outlets. I had absolutely no trouble.

MR. TAYLOR. We very seldom contract any work that we can do ourselves. The 48-in. job is handled very comfortably with the present outfit. I had estimates made of the cost of steel and cast-iron mains for that job, getting a contractor's figure for 48-in. main, and using our own estimate of our own cost of laying a 48-in. cast-iron main and comparing it with the contractor's figure for a 48-in. steel main.

We could, by doing the work ourselves, put in the cast-iron main for about the cost of a steel main through contract, and the difference in value is considerable, or, at least, that is my opinion. You get a 48-in. cast-iron main by doing the work yourself for the price of a steel main by contract.

*Foreman Water Dept., Worcester, Mass.

PRESIDENT BARBOUR. I think that is a most remarkable statement that Mr. Taylor has just made. I think you had better add, if you can, the price of cast-iron at the time the comparison was made.

MR. TAYLOR. At the time cast-iron was high. My estimate was based on $70 per ton. Steel was also high, of course. I should think the difference between steel and cast-iron was less now than it was twenty-three years ago when the old system was laid. At that time there was considerable difference, and it was figured that the interest on the difference in cost — both by contract, of course — in twenty years would re-lay the main, of course using the prices of that date as a basis.

But as a matter of fact we all know that the prices are very much higher now.

MR. BRUSH. Have you found any corrosion on the exterior of your steel line?

MR. TAYLOR. No. All interior, from tuberculation and pitting.

MR. BRUSH. Have you had any failure in the entire line?

MR. TAYLOR. No absolute failure.

MR. BRUSH. Have you estimated about how much longer that line will last? I know you stated that you were putting in cast-iron as a security against possible failure of the future.

MR. TAYLOR. Yes.

MR. BRUSH. You said that some of the pitting had gone through just under one-half the thickness of the metal.

MR. TAYLOR. About that. Very roughly we have estimated that we ought to get fifteen years more life out of the steel pipe. That is on what we have seen. Of course we do not know the condition in some places where we have not seen it. But we felt it was a much safer measure to have this second main in readiness if it did let go.

MR. DIVEN. That will make a total of thirty-five years?

MR. TAYLOR. Yes, if it runs fifteen years longer, thirty-eight years.

MR. DIVEN. What kind of soil is it laid in?

MR. TAYLOR. A little of everything; swamps, gravel, and some few clay spots.

MR. DIVEN. Any pitting in the clay?

MR. TAYLOR. I have not seen any piece from outside where there was any pitting. I perhaps ought to say that we have not uncovered very much.

MR. DIVEN. My experience is just exactly the opposite. Especially in clay soil there is more pitting from the outside than the inside.

MR. TAYLOR. We make frequent tests for leakage in that steel main by the weir chamber, shutting off all outlets and noting the drop in the very small weir chamber, and it has been very tight every time it has been tested. We are not guessing, but know it by actual test.

# A NEW METHOD OF PURIFYING WATER.

BY H. W. CLARK.*

[*September 14, 1922.*]

Probably the chief objection to slow sand filtration in the minds of many sanitary engineers and water-works officials is that this method of water treatment seldom removes from the comparatively clear but often highly colored waters of the eastern states more than from 25 to 30 per cent. of this color, and hence does not produce a filtrate as clear, sparkling, low colored and altogether attractive as the filtrate from coagulation and rapid filtration of such waters. On the other hand, perhaps the chief objections to the method of coagulation and rapid filtration when applied to these soft, highly colored waters, are; the tendency of this method to increase the corrosive properties of the soft water treated, the difficulty with which, as generally speaking, equally good bacterial results can be obtained, as by slow sand filtration, especially if these soft waters are badly polluted; and the fact now again being widely commented upon that occasionally aluminum sulphate does pass through such filters.

Owing to these objections or criticisms of the two methods, a process of water treatment that will produce a sparkling water of low color without materially increasing its corrosive properties, has been much desired and such a method I believe we have worked out at the Lawrence Experiment Station of the Massachusetts Department of Public Health. I am calling this a new method although we have been experimenting with it since the latter part of 1916 and have published in our reports short summaries of the results obtained.

Briefly, the process consists of loading the sand of a slow sand filter with the ordinary coagulants used in mechanical filtration and operating such a filter generally at slightly more than the usual slow sand filter rates or about 5 000 000 or 6 000 000 gal. per acre daily. Filters loaded in this way remove a very large percentage of the organic matter, especially the coloring matter of the applied water, produce an effluent clear, sparkling and altogether attractive, containing no more carbonic acid than in the raw water applied to the filters and with the carbonate constituents of the water slightly increased.

This method of water treatment has many advantages over each of the other methods and but one drawback. The advantages are as follows: (1) The corrosive properties of the effluent are not increased or if so, not materially, and neither aluminum sulphate nor alumina is found in the filter effluent; (2) the aluminum hydroxide with which the filter is first loaded is regenerated whenever its color removal properties begin to

* Chief Chemist, Massachusetts Department of Public Health.

fail and hence is used over and over again, — that is, the primary cost of coagulants is practically the final cost; (3) when receiving comparatively highly colored water from storage reservoirs practically free from mineral matter in suspension, such as silt, etc., the method of filter regeneration or removal of stored color which we employ, removes practically all organic matter from the surface of the filter as well as from its deeper portions and hence the necessity for scraping the filter is largely obviated, — that is, the expense of sand removal and sand washing is reduced to a minimum. Filters of this type now in operation at the Experiment Station have been scraped only once or twice during a period of five years' operation at rates of 5 000 000 gal. per acre daily; (4) there is, as I have already stated, practically no consumption of alum. Filters operated now for five years have theoretically used up to date, taking into consideration the amount of aluminum sulphate primarily placed in the filter and the volume of water filtered, about .2 of a grain of sulphate per gal. of water filtered or practically one-twelfth of the amount necessary per gallon in sucessful mechanical filtration of the Merrimack River water such as applied to these loaded filters. As the loaded filter increases in age and the volume of water filtered and decolorized increases, the theoretical or apparent use of alum grows less and less per gallon. Successful mechanical filtration of Merrimack River water costs in the neighborhood of $6 or $7 per million gal. for aluminum sulphate while with this new method the cost to date has been about 55 cents per million gal. for this sulphate, and this cost is constantly growing less: that is to say, if in the next five years we filter as large a volume of water as in the past five and without additional loading of the filter, the cost will be 28 cents per million gal.

Up to date we have operated eleven filters loaded with aluminum sulphate but for purposes of this paper the results of only five or six need be given. One filter, put into operation in January, 1917, and constructed of 4 ft. in depth of sand with an effective size of .25 mm., was loaded with 80 tons of aluminum sulphate per acre of filter surface. The aluminum hydroxide was precipitated in the sand by flooding the filter alternately with small doses of solutions of soda ash and sulphate, although the filter can be loaded by mixing an alkali such as magnesium carbonate with the dry sand and then applying solutions of the sulphate. During its five years of operation the average color of the effluent from this filter has been 14 and the color of the water applied to it, 41 — a removal of 66 per cent. During long periods the color of the effluent has averaged 7, however, and during portions of these periods the applied water has had a color of 60, 70 and even 75: that is, the filter has given an average color removal during such seriods of about 90 per cent. In other words, the line of the effluent has always been nearly straight while the color of the applied water has had many high peaks and the higher the color of the applied water the greater the percentage of the coloring matter removed. Up to date this filter has removed rather more than 50 per cent. of the

organic matter determined as albuminoid ammonia and 60 per cent. of that determined as oxygen consumed. It has been treated with weak solutions of caustic soda twenty-four times in five years in order to remove the coloring matter held in the filter by the aluminum hydroxide. After this treatment with caustic such a filter is washed with a volume of water equal to about 2.5 to 3 per cent. of that filtered between treatments and is then ready for service for a period of two or more months. It is not necessary to use filtered water for this washing out of caustic. The amount of caustic used up to date in the filter described has been .5 of a grain per gal. of water filtered, or, in other words, the expense for the caustic used has been about $2.50 per million gal. of filtrate. We believe, however, judging from later results that we have used in this particular filter an excessive amount of caustic and that this figure may be much reduced. A filter loaded with 150 tons of aluminum sulphate per acre has given an average color removal of 78 per cent. during the past two years when operated at a 5 000 000-gal. rate and a filter constructed of sand as fine as .11 mm. effective size and operated at a 2 500 000-gal. rate has produced an absolutely colorless effluent since first put into operation. The cost of efficiently loading an acre filter is a small percentage of the cost of filter construction.

The bacterial results from this method are poor as the caustic used removes from the sand grains much of the gelatinous organic matter so necessary for the retention of bacteria; but the effluent—clear, low in color and sparkling—is easily rendered practically sterile by the use of small amounts of chlorine, and chlorine is in almost universal use at filter plants at the present time in order that their effluents may be absolutely safe.

This method of treatment is particularly applicable to stored waters of a high color, the improvement of which physically is of more moment than the reduction of bacteria; and it has seemed to us that there is no serious objection to it which would prevent its use upon a large scale. Recent experience has shown that perhaps the better way of loading the sand would be to carry this loading process on in comparatively small tanks or bins and then transport the sand to the filter. By this method more even distribution of the hydroxide would be obtained and stratification prevented.

The following table illustrates some of the results obtained at the Experiment Station during the past five years:—

| | Filter Number. | | | | | |
|---|---|---|---|---|---|---|
| | 494. | 512. | 513. | 514. | 515. | 516. |
| Tons of aluminum sulphate per acre precipitated in filter, | 80 | 75 | 75 | 150 | 150 | 225 |
| Color removal (per cent.), | 66 | 73 | 73 | 73 | 78 | 76 |
| Number of days between caustic treatments, | 65 | 67 | 67 | 89 | 89 | 90 |
| Grains of caustic soda used per gallon of water filtered, | .52 | .21 | .42 | .16 | .32 | .16 |
| Approximate percentage of wash water, | 2.5 | 3.7 | 3.7 | 2.8 | 2.8 | 5.5 |

Rate of each filter 5 000 000 gal. per acre daily.

## Discussion.

A Member. Does the aluminum hydrate come through the filter at all?

Mr. Clark. Not after you get the loading adjusted. When loading the filter you may not get your proportion of soda and sulphate just right to cause complete precipitation of hydroxide, but by testing the water coming through you can adjust that.

Mr. George W. Fuller.* I would like to ask whether during the period of some two months or so between regeneration of the hydroxide there is any diminishing percentage in the removal of color; in other words, is the greater the amount of aluminum hydrate you have available the greater the removal of color, so that during the first ten days after you regenerate you get a less of color?

Mr. Clark. Yes. When you are running a single filter, this filter removes all color at first from the water and then when the color of the effluent gets up to 14 or 15 we regenerate the filter. If you have a battery or series of filters, by regenerating each one separately the increase in the color of the effluent as the filters are used would not be noticeable; that is to say, the color of the mixed effluents could be kept at the desired point.

A Member. Is regeneration of the filters carried on by reversing the flow?

Mr. Clark. We flush the caustic over the surface.

Mr. Robert Spurr Weston.† When you regenerate with caustic soda, you of course reduce the amount of hydrate available for the decolorization?

Mr. Clark. We have not found any appreciable amount is taken in that way.

Mr. Weston. You do not, after regeneration, need any replacement of the original loading?

Mr. Clark. We have not replaced any in five years, and our filters are working just as well as they did five years ago, i.e., removing just as much color. We may be losing some slight amount of aluminum hydroxide from the filters but have never found any in the effluents.

A Member. One question occurs to me along that line. Some highly colored swampy waters that are decolorized require a large amount of aluminum hydrate to get as nearly colorless a water as you can obtain but this does not remove the salts or acids that cause taste. They may have been decolorized but apparently the swampy taste is not removed. Did you consider that at all?

Mr. Clark. We have not considered that but our effluents are practically tasteless. The Merrimac River water at times in the last two or three years, especially the last year, has been very highly colored.

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*Consulting Sanitary Engineer, New York City.
†Consulting Engineer, Boston. Mass.

MR. FULLER. Of course economics of this problem would relate a good deal to the amount of turbidity, mineral turbidity or microscopic organisms like *Algae* in the applied water, and then your regeneration period would be controlled by other matters than the amount or organic matter held in the filter sand.

MR. CLARK. The regeneration period would not be changed. It would be necessary probably in such a case to scrape the filter just the same as it would if you did not have it loaded with aluminum hydroxide, as you would any sand filter receiving such water.

MR. J. M. DIVEN.* Then after scraping you would not have to recharge?

MR. CLARK. No.

MR. GILBERT H. PRATT.† Unfortunately I did not hear all of Mr. Clarke's paper and he may have covered the point I am about to inquire about. I am wondering whether in loading the bed this has been done by the aluminum sulphate — soda ash treatment to successive small layers of sand or to the bed after in place. If the latter, it would seem to me that there would be a heavy layer on the top of the bed and as I said before I am wondering if it was done by treating successive small layers.

MR. CLARK. I think by doing that you might perhaps, once in a while, get a stratified layer, a fine layer; that is, your aluminum hydroxide precipitate might be too heavy at one place in the filter. As I said in the paper, you can obviate that by having bins or tanks in which you charge or load your sand before placing in the filter.

MR. PRATT. My point was whether you thought you had a heavier layer on the top possibly?

MR. CLARK. We may have a heavier layer on top if the filter is not properly loaded but it is easy to load the filter correctly. I think one of the great things about this method is the low cost for aluminum sulphate. When you come down from $5 to $6 a million gallons to 55 cents and then keep on going down so that it is perhaps half of that before you have to use any more precipitant, you are making a great point on the economy side. I have more data on this subject but haven't it with me because I did not want to talk about things that I was not absolutely sure about.

MR. WESTON. Is there any material change in the pH value of the water?

MR. CLARK. Yes. The pH value of the water is increased. We are running a mechanical filter right beside these filters with the same water and the pH value of the effluents from our loaded filters is greater than the effluent of the mechanical filter.

MR. F. W. GREEN.‡ Can you see the aluminum hydroxide in the sand layers?

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* Secretary American Water Works Association, New York City.

† New England Manager, Wallace & Tiernan Company, Newark, N. J.

‡ Superintendent Filtration & Pumping, Montclair Water Co., Little Falls, M. J.

MR. CLARK. It is very difficult to see it unless a portion of the filter is over-loaded.

MR. WELLINGTON DONALDSON.† May I ask Mr. Clark what strength of filter solution is used in filling or loading a filter?

MR. CLARK. Very weak solutions as very slow loading is required.

MR. M. N. BAKER.‡ In the paper it is stated that there are four or five advantages and one drawback and the drawback is not clearly pointed out anywhere in the paper. Perhaps the author of the paper would mention more specifically what the drawback is.

MR. CLARK. The drawback is the poor bacterial results. The process as we use it removes about 75 to 80 per cent. of the bacteria as determined by the 4-day 20°C. count and a larger percentage of *Coli* is removed but the bacterial efficiency of the filter is nothing like that obtained by good sand filtration or good mechanical filtration. As I have stated, the process is particularly applicable to the treatment of waters, the physical improvement of which is of more moment than bacterial improvement.

MR. GREEN. This most interesting paper of Mr. Clark's apparently shows the existence of certain physical-chemical properties of aluminum hydroxide of which we have no former record. These properties may account for the mutual precipitation which is brought about when a colored stream and a turbid stream are intermixed by Mother Nature.

When a solution of aluminum hydroxide is applied to a colored water the floc forms much more quickly than when a solution of sulphate of alumina of equivalent value reacts with the alkaline constituents of the same water. The decolorizing action of the more slowly formed floc is much greater than that produced when the floc is formed rapidily. It is possible to form a floc so rapidily that masses of considerable size are produced before there is a reaction with the organic coloring matter contained in the water. Only the surface of the individual particles is stained, the interior remaining white and thereby showing that it has not participated in the decolorizing action. Some recent experiments by the writer with a certain colloidal coagulant which is now being introduced on the market,* also show that it increased the reaction with the organic constituents if you retarded the formation of the floc.

In connection with cleaning sand by means of caustic soda, we have found by laboratory experiments that it is possible to remove all of the organic matter from the sand grains by this method. Also that a hot solution of the mixture of acaustic soda and soda ash gave the same results at a lesser cost.

It would be of interest to know if there is a coating of the alumina on the sand grains, or just what is the physical condition of the hydroxide.

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† Chemist, Fuller & McClintock, New York City.

‡ Associate Editor, *Engineering News Record*, New York City.

* Sendel's Colloidal Coagulant. Seydel Chemical Co., 120 Broadway, N. Y.

MR. STEPHEN DEM. GAGE.* I have been very much interested in Mr. Clark's paper for the reason that, with one or two exceptions, our water purification problems in Rhode Island are concerned with color removal and improvement in physical quality, rather than with removal of pollution.

From the figures which Mr. Clark has presented it seems that this new process might have considerable value in particular cases even if experience shall show that it is not of broad application. The more processes we have to choose from, the more satisfactorily and economically we can work out our individual problems. In explaining the figures on the chart, Mr. Clark specifically mentioned a color removal of 66 per cent. with a filter containing 80 tons sulphate of alumina and an increased color removal with a filter containing 150 tons per acre. The chart also shows results with two other filters containing 75 tons per acre with a color removal of 73 per cent., or almost as great removal as the filter containing 150 tons. This might perhaps indicate that there was a certain definite load of alum needed to produce the best results, and that any material increase over that amount would not be worth while. I should like to ask Mr. Clark if he can give us any further information on this point.

MR. CLARK. I did not. We did get 73 per cent. removal with 75 tons of aluminum sulphate.

MR. GAGE. Is that related to the fineness of the sand?

MR. CLARK. The fineness of the sand in our filters was as nearly the same as we could have it.

* Chemist and Sanitary Engineer, Rhode Island State Board of Health.

# THE USE AND DISCARD OF AUXILIARY FIRE PROTECTION FROM A POLLUTED SOURCE.

BY CALEB M. SAVILLE.*

[*September 13, 1922.*]

The matter of secondary fire protection by use of water from a polluted source, controlled by automatic check valves designed to close when the secondary supply is turned on, has been the subject of so much discussion within the past few years that it seems desirable to put on record some of the experiences that have been passed thru in Hartford, Conn.

The intent is to state the facts from the water works standpoint, and to complete some of the statements which have appeared from time to time in favor of such systems.

Hartford, Conn., the home of the largest fire insurance companies in the world, was the first to sanction the use of the so-called Double-Check Valve control between its public water supply system and a secondary source of water to be used for fire protection.

It is therefore of interest to note that after a trial period of 13 years, Hartford also has been the first city to discard such control and to require the complete severance of all connection between its water system and any other.

These connections joined city pipes, carrying carefully filtered water, with pipes into which might be forced water flowing in the Park River, which is dirty and foul with sewage and waste. Under certain combinations of circumstances this water would be injected into the pipes carrying water for domestic use.

## HISTORY.

Historically and briefly stated, the fact that there were a number of emergency connections between the Park River and the City water mains only more or less controlled by check valves of the ordinary type, buried in the ground, was brought to the attention of the Water Board of the City of Hartford in August, 1907, by Mr. E. M. Peck, a member of this Association and Engineer of the Board at that time.

An order was issued by the Board soon after, directing discontinuance of the connections; but after several conferences with the manufacturing interests affected it was agreed to stay the execution of the order until trial could be made of a double-check valve combination which had been designed by the engineers of the Associated Factories Mutual Fire Insurance Company.

*Manager and Chief Engineer Board of Water Commissioners, Hartford, Conn.

These installations were completed by February, 1909, and their operation was described on page 239, vol. 30, JOURNAL N. E. W. W. A. (1916).

The matter did not come up again until July 1915, when the writer of this paper reported to the Water Board that "the valves very frequently are found not to close tightly, due to foreign matter being caught on the seat under the clapper." Owing to the very nature of the service a valve left absolutely tight by the inspector may be found leaking again soon after his visit, although he had left the valve perfectly tight.

For example, in 1921, and this is only one of several instances on record, although perhaps the most aggravated case, from January 20 to March 19, inclusive, because of failure to hold tight on test, the same valve was visited eight times, and each time found to leak on test, and each time put in order and left tight when tested.

The Associated Factory Mutual Inspector also made a test during this period, found the valve leaking, repaired it, as had the water-works inspector five days before, left it tight, and nine days later the water-works inspector again found it leaking.

The report of the inspector states each time that the valve seats were found dirty, and had to be scoured, and several times the rubber seat ring had to be changed around or renewed.

In most every case the emergency supply was taken from the excessively polluted Park River, a stream draining about 60 sq. mi. including thickly settled parts of the factory district of New Britain, the center portion of West Hartford, as well as the congested part of Hartford.

That there is a real danger in such connections is evidenced by the epidemics of typhoid fever traced to connections between the public water supply and polluted streams, as at Circleville, Ohio, February, 1914, Philadelphia, Pa., 1913, Springfield, Ohio, 1911, New Bedford, Mass., 1903 and others. The fact that there may have been no improved type of check or possibly only a gate valve on these does not weaken the evidence of potential danger in the connection, at most such installation could be only one more barrier and not a preventive.

December, 1915, this matter was again before the Board on recommendation to refuse thereafter permission to extend the system, and the recommendation was adopted although protested by the Engineer of the Factory Mutual Companies.

September, 1918, the matter of connections was again brought to attention, by the continued presence of *B.Coli* in the tap water at the laboratory, which is located near the center of the city.

An exhaustive search located the trouble in a large department store where there was an emergency connection between the city water supply and a secondary supply drawn from a well driven several hundred feet into the red sand stone formation underlying the city, and from which water was pumped into a tank on the roof of the building.

Controlling this connection were two check valves of the ordinary type.

This sandstone layer dips toward the east and is crossed by the Park River, from which the factories drew their secondary supply in case of need. There are many of these wells in Hartford being used to furnish cooling water for refrigerating plants. Many tests of the water from these wells have shown the presence of *B.Coli* in those east of the river, but none in those to the west. The assumption therefore seems warranted that there is direct connection by fault or seam between the river and the wells.

The connection causing the trouble was ordered removed forthwith, and on September 25, 1918, a special committee of the Water Board recommended that an order be issued for the disconnection and subsequent prohibition of all connections between the city water system and any other supply. This recommendation was approved by the full board, and the order issued, to be effective within a reasonable time after notice.

Believing their factory plants to be seriously menaced, the manufacturers affected, again ably supported by the engineers of the Associated Factory Mutual Insurance Cos., made a strong protest against the operation of the order; brought in an eminent sanitary specialist to give his opinion of the comparative danger from pollution or from fire; another engineer to give general testimony; and designed, and built at considerable expense a full sized model valve all of bronze, with rubber gaskets of specially prepared material, which they offered to install in the place of the "F.M." valves then in service, and which they and their specialist now frankly acknowledged to be unsatisfactory.

Through all of the controversy the manufacturers acted in the very best spirit, as good citizens, open-minded and anxious only to have that protection to which their plants as important to industrial well being of the city were entitled. Indeed, after the matter was finally disposed of, some of them said that they had been misled as to the adequacy of fire protection afforded by the city departments and if they had been previously as well informed they would not have opposed the order as they did. At one of the first meeting a prominent manufacturer said that the matter of cost did not enter in, the only consideration being proper protection, and subsequent actions fully bore out this assertion.

It is also pertinent to say that the all bronze valve designed by Mr. C. D. Rice, manager of the Underwood Typewriter Plant, is by far the best mechanism of its kind that has come to my knowledge, and the nearest substitute for actual severance of connections, although in my opinion there is a very wide chasm between no connection at all and one controlled even by the Rice valve.

However if you must have double-check valves insist that all bronze valves of the Rice type be furnished.

Thereafter several hearings were held by the Board at which interested parties appeared and submitted testimony concerning the necessity for

continuance of the connections for fire protection service and of the very remote chance of pollution of the city water.

At one of these meetings the present installations were roundly scored by one of the best known sanitary experts of the country, who appeared for the manufacturers to testify as to the very remote chance of pollution and the relative danger of considerable loss by fire and of loss of life by polluted water from these connections.

Even this specialist, however, stated that "there was some danger in any connection of the public water supply with a polluted source, and that as a general rule health officers and practical water-works operators are opposed to connections of this character; nevertheless, that he believed that such connections could be made of little danger if controlled by a properly designed check valve system; that the present design was not satisfactory, the chief difficulty being that there was a danger of binding of the hinge and of rust and pipe moss becoming lodged under the seats." He further suggested that "these difficulties could be largely overcome with the construction of a bronze valve differing somewhat from those at present in use." He would not admit, however, that even with such a valve there would be absolutely no danger, but stated that he did believe that with such a valve the danger of pollution could be so reduced that it would be of less importance than the dangers to life and property from insufficient fire protection.

On November 15, 1920 it was again voted to proceed with the disconnections.

Again, however, at the request of the manufacturers, who wished to submit additional testimony and to have consideration given to an all-bronze valve which they had had built and installed on a test connection, two other hearings were held, at which time, beside the manufacturers and their attorney, there were also present a representative of the Associated Factory Mutual Fire Insurance Company (Inspection Department) and a representative of a New York Engineering firm who had been retained by the remonstrants.

After this hearing the matter was finally closed by reaffirmation of the order to disconnect, with time extended to January 1, 1922, the last hearing having been held July 11, 1921, and the manufacturers at once proceeded to install other means to give service satisfactory to the fire insurance underwriters.

In all of this discussion nothing but the best of feeling prevailed between the manufacturers and the Water Board or its employees, and when the final decision was reached the manufacturers as a unit acted as good sports and good citizens; they accepted the verdict with good grace and without quibble went to work to carry out the spirit as well as the letter of the order.

As the hearings progressed the impression was given that the insurance interests most concerned were more disturbed on account of the general principle of disconnection than with its particular effect in Hartford.

It is noteworthy that none of the fire insurance stock companies made any objection to the elimination although, as stated, the principal offices of the larger companies are located in Hartford, and their engineering staffs were thoroughly informed.

The manufacturers stated that it was not at all a question of expense to them in making the substitution, as their only concern was adequate fire protection, and that they had been led to believe that this could be afforded only by the double-check valve connections. This contention of the manufacturers was also clearly evident by their attitude and sincere effort to find some substitute which could be considered the equivalent of complete separation.

Notwithstanding this it is not known that there was any increase in insurance rates due to the change, and in one case it is stated that a considerable saving was effected by the rearrangement.

Leading up to the accomplishment of separation of the secondary supplies, so much study was given to the matter generally and to local conditions in particular that a résumé may be of help to water-works men in more readily getting some information which in many of its phases is of vital importance to those responsible for furnishing pure and safe water to consumers.

### Auxiliary Connections Prohibited.

In order that absolute protection of their water supplies may be had, many cities absolutely prohibit connections between the city water supply and any other source. Among these are Springfield, Mass., Providence, R. I., Lowell, Mass., Philadelphia, Penn., St. Paul, Minn., Cleveland, Ohio, Stamford, Conn., and Terre Haute, Ind.

The Minnesota State Board of Health absolutely prohibits these connections and has ordered out existing ones; the State Board of Health of Illinois "sanctions no such physical union in the installation of new factory supplies."

### Legal Responsibility to Supply Safe Water.

In reviewing the "Mankato Typhoid Case" where damages were claimed and paid for typhoid death and disease due to polluted water entering the city mains, the Supreme Court of Minnesota said;* "It is obvious, that a sound policy holds a city to a high degree of faithfulness in providing an adequate supply of pure water, nor does it appear why citizens should be deprived of the stimulating effects of the fear of liability on the energy and care of its officials; nor why a city should be exempt from liability while a private corporation under the same circumstances should be held responsible for its conduct and made to contribute to the innocent persons it may have damaged."

*Jour. A. W. W. A., Jan., 1920, page 47.

In denying the application for reargument, in the same case, the Court made the following statement; "The decision rested in effect upon this supreme consideration; namely, that public policy requires the conservation of human life, the preservation of the public health, and the establishment of public sanitation on a firm and certain basis in the law."

### Secondary Supplies Desirable.

Secondary sources of water supply are desired because of the risk of one means of fire protection being inadequate or out of commission in the emergency, and fire insurance underwriters properly give somewhat lower rates to factory risks having such connections.

### Methods For Obtaining Secondary Supply.

This secondary supply may be obtained in several approved ways; by use of elevated tanks, by use of large cisterns underground, or by connections with a stream. So far as is known, there is no difference in rate due to the use of any of these modes. In the two methods first mentioned city water may be used to fill tanks and act as a reserve, or polluted water may ordinarily be used with the city water entering above the highest point to which the impure water can reach. In the third case highly polluted water may be used separated from the domestic supply only by automatic check-valves.

### Check-Valves Leak.

Check valves and gate valves of any and all kinds leak more or less at times and there can be no positive assurance that any of them are absolutely tight at all times. Record of test of double check-valves in Hartford during the past 10 years disclose 61 occasions on which leaky check valves have been reported. Of these, on 34 occasions there was leakage in the outer check, 21 occasions leakage in the inner check and 6 occasions leakage through both checks. In two cases of different sets, leakage through both sets was found on two successive monthly inspections although the valves were left tight on the first inspection. There is, however, no question that at any time a zealous employee may directly by-pass the double check in his endeavor to improve the factory water system without realization of the danger of pollution to city supply.

### Park River Not Drinking Water Supply.

The Park River is badly polluted, and if its water finds a way into the city mains an epidemic of typhoid or similar disease is probable.

### Typhoid Epidemic Due to Leaky Check Valve.

In 1903 a single check valve, said to be specially built and the best of its kind, failed in Lowell, Mass., when subjected to similar conditions to which the Hartford double checks would be subjected in case of fire; and the result was an epidemic of typhoid fever in which 9 persons lost their lives and 172 persons were incapacitated for a greater or less period due to illness. The financial loss in life and health in this community due to this epidemic can be estimated to have been in the vicinity of $100 000. The fact that in this instance there was a single check instead of a double one is of relative importance only.

### Limited Use of Double Check-Valve System.

The double-check valve system in Hartford was used by eight of all the factories here located, the remainder using tanks of some kind for secondary supply when this is required.

### Small Openings a Source of Danger.

A small crack under a check valve such as might be caused by a particle of rust, sand or other foreign body, or the sticking of the hinge due to corrosion, might prevent the clapper of the valve from seating and allow as much water to be forced through by a fire pump on a double check-valve as it is estimated was responsible for the trouble emanating from the auxiliary supply mentioned above.

### Right of Board to Order Disconnection.

As to the right of the Board to prohibit the use of auxiliary connections and order disconnection of those now in use, it appears that the installations exist under what may be considered as a revocable license subject to order of the Board of Water Commissioners, who are responsible for protecting the purity of the water supply. The earlier leanings of the law toward granting precedence to property rights over rights of personal protection have gradually been changing, and at the present time it is generally recognized by the courts that protection of life and health is paramount to protection of personal property. In order to show just cause for order to discontinue any nuisance prejudicial to public health it is probable that the courts would hold it unnecessary to prove the actual occurrence of disease and death resulting therefrom, and would require only reasonable evidence that the continuance of the nuisance might produce conditions which would be detrimental to the welfare of the community.

### Double-Check Device Best Protection of its Kind.

The double check device is probably the best of its kind if automatic connections must be had between a polluted source and the city water supply. That this device, however, is not perfect is indicated by the corroded condition of the interior of the present valves, the constant supervision to keep them in even approximately usable condition and the fact that the underwriters' design itself has been modified from time to time in the matter of seat rings, valve facings, distance of valves apart, and the necessity in at least one case of using an auxiliary weight on the clapper to make the valve seat tight. In order to give more assurance of tight closing under pressure it is now found necessary to insert a rubber gasket in the face of the valve. While the rubber is in good condition this makes a tighter joint than the previously ground face. On the other hand, when the rubber becomes worn or the life goes out it peels off, in places, and leaves a larger opening for water to go through.

### Chance of Failure of Valves.

Absolute safety lies only in physical separation of these two services. With the character of inspection which has been given in the past, the chance of pollution with these check valves on fire protection connections only, must be recognized as probably remote. While such connections exist, however, the chance exists that at some time there will be failure, and conditions serious to life and health will obtain in the city water supply.

### Double-Check Valve Systems Allowed by Public Bodies.

The statement is made that certain public bodies have allowed the use of this check valve in water systems. It appears from correspondence that this permission is not at all a general one, has been reluctantly given in special cases, and none of these bodies appear to consider this check valve an alternative for complete disconnection as a safeguard to public health. In most cases, where the device is allowed, there are many restrictions placed on the use, which is also limited as regards number of connections and character of the secondary supply. On the other hand, all of the Boards of Health state that absolute safety is obtained only with no connection with a polluted source and defend their action in allowing the check valves on the ground of policy and expediency. Many other cases can be cited where no automatic connection whatsoever is permitted between the public water supply and a secondary source.

### Financial Loss from Epidemic Comparable with that of Fire.

The financial loss to the community in case of epidemic is fully as much as, if not greater than that in an exceptional fire.

Johnson states that the failure of a double-check valve to act properly at the right time is a greater menace to health than fire, and incidentally he

adds that in the United States in the past 30 years the vital capital dissipated by typhoid fever was over three times the net property loss from fire, "so in questions like this, offering a choice between the loss of life and the loss of property, there should be no hesitation in lining up on the side of health."

### Opinion in Regard to Double-Check Valve Connections.

In connection with this matter, the opinion of Mr. Leonard Metcalf, one of the best informed engineers in the country on matters relating to municipal and sanitary work, may be of interest (*Proceedings Am. W. W. Assoc.*, 1912, p. 174) in his answer to Mr. J. Walter Ackerman, Supt. of Water Works, Auburn, N.Y., who asked what chance there would be for pollution in the case of the then recently installed double-check valves in that city. Mr. Metcalf said: "In regard to the desirability of using a double-check valve, this decision must be reached after very careful consideration of all the local conditions. Health should unquestionably be first taken into consideration. If you have a city supply used as a primary supply, not as a secondary supply, but as a primary supply, and a secondary supply which is reasonably safe, it would seem that there should be no question but that a double-check valve, with proper inspection at stated periods by water-works departments as well as by insurance agents, might be adequate, particularly in those cases where the pressure maintained on the risk side of the check valves is less than the pressure maintained in the city mains. *If you have, on the other hand, a secondary supply, or even a primary supply, taken from such a stream as Bubbly Creek*, undoubtedly you have no right to take the hazard of installing even a double-check valve system, because the dangers of injury to the public are altogether too great;* so that you must take into consideration in making your decisions, first, the question of the character of the primary supply and of the secondary supply, admitting always that it is desirable that the primary supply should come from the pure public supply; second, the relative pressure maintained on the two pipe systems; third, the character of inspection which you can be sure that you will get.

"As to the effect of corrosion on the double-check valves, it would seem that this is met by inspections. If you have periodic inspection, the inspectors must know what the condition of the valves is, but even in that case, if the secondary supply is much polluted, the speaker would not want to rely upon a double-check valve."

Where the line is between Bubbly Creek water and that which is absolutely safe, it is then a matter of individual judgment, and the part of the supply man is to play safe with human life, because if the one chance in a million of a typhoid bug getting by and causing an epidemic, does materialize, it will not be the insurance company engineer who will have the burden.

*A highly polluted stream in Chicago Stockyards.

### Large Factory Fire Supplies a General Risk to the City.

The increased risk of fire damage and conflagration due to elimination of secondary supplies in a city as well safeguarded as Hartford in its public water system is as nothing compared with the risk put on the whole fire protection of the city by the sprinkler supply systems in the larger factories. A broken sprinkler main might so reduce the pressure in the city system as to put a much greater risk on the general fire hazard of the city than it is possible to place on the individual hazard of any factory by the elimination of the secondary supply.

### Adequate Fire Protection Without Risk to City.

It is very truly stated in the letter of the manufacturers that "no practicable substitute supply can approach the equivalent of the protection now afforded by the public water supply through our sprinkler systems." It is, therefore, fair to presume that this advantage is reflected in the rates given to individual plant owners.

In the case, therefore, where a secondary supply is desired, and an adequate one may be obtained without suspicion of danger to the health of the city, even if some expense is put on the individual, little if any actual hardship is imposed in the view of the special gain enjoyed by the individual from use of the city system as a primary supply for the protection of his property. Moreover, if it is a hardship on the few to lose the source of secondary supply under consideration, this loss is measurable in dollars and cents; whereas if there is any loss of life due to the introduction of polluted water into the city mains, an irreparable hardship has been placed on the many, because life and health are not to be appraised adequately by any financial measure.

### Private Fire Systems Mostly for Private Advantage.

As to public advantage derived from factory fire protection installation, special gain to plant owners from the benefit derived by them from a public water supply connection to sprinkler systems, has been too often recognized by the Courts in rate cases to warrant any successful argument to be made of a paramount advantage to the city in safeguarding life and property by such installations.

### Importance of Manufacturing Industries Recognized.

The Water Department of the City of Hartford has fully recognized the importance of its manufacturing interests to the existence and prosperity of the city. The benefits accruing to the city from adequate private fire protection systems in safeguarding the lives of its citizens employed in factories and consequential damages resulting from spread of fire to other plants and the losses resulting from interruption of business has been carefully considered and generously met by this city department.

### Advantageous Conditions.

For example, no charge is made for the large supply mains under high pressure, nor for the ready-to-serve feature of the city supply which allows of very large reductions in insurance rates to plant owners, a condition considered by the courts as a benefit not incidental but as a peculiar service provided in general. In many cities of importance, annual charges are made for connections of large size whether or not used, and often times a charge is also made for each sprinkler head installed. No charge is usually made for water used for extinguishing fires; but a meter is often installed on all fire lines in order to prevent surreptitious use of water and to allow of a charge being made for leakage and waste in factory systems. None of these methods have been pursued in Hartford.

### Editorials in re Cross Connections.

Pertinent to this subject, excerpts from two editorials appearing in the Engineering press are of interest as showing the trend of public opinion. (See Appendix G.)

*Fire and Water Engineering*, January 21, 1920. "The Trend Toward Safer Water"—"If a city is responsible for the condition of its public highways and is liable in case of injury resulting from neglect of proper care, how much greater is the responsibility when the same neglect puts in jeopardy the health of an entire community."

*Engineering New-Record*, May 13, 1920. "Leaky Cross-Connection Kills Fifteen," commenting on the result of a leaky valve which admitted polluted water to the city mains.

"Unfortunately there are still some engineers, especially those in the employ of the fire insurance companies, who see no harm in cross-connections or who put property risk above life risk."

In view of the above facts and after careful consideration of the subject of dual connections existing between a public water supply system and a polluted source, here and elsewhere, the following recommendation is respectfully submitted:

### Loss of Life by Fire.

In some of the cases the author has read, advocating the use of the "F.M." Double-Check Valve as a water safeguard, reference is made in several cases to the large loss of life in the burning building, and the inference drawn was that had there been double-check valves the regrettable condition would not have occured.

Most of these references have been looked up, replies were received from a majority of them and in every case the answer was that the loss of life was due neither to lack of water nor of fire fighting apparatus but to inadequate means of exit or to flimsy building construction.

## State Sanitary Engineers Conference.

At the conference held at Boston, Mass., June 1, 1921, the matter of cross-connections was taken up and thoroughly discussed. As the accounts of the conclusions of that body have been somewhat misleading because of partial quotations, it is desired to state here the main principles of that valuable report and it is hoped that the whole body of conclusions may be included in an appendix.

*Principle No. 1.* No cross-connection should be established or maintained between the public water supply system and any other water supply system, private or public, unless both water supplies are of safe sanitary quality and both supplies have received the approval of the State Health Department.

*Principle No. 2.* In cases where it is necessary or advisable to supplement an impure private water supply with the public water supply, distributed in the same piping system, the public supply must be made available by delivering it into a cistern, suction well or elevated tank at an elevation above the high water line of such cistern, suction well or tank.

Then follow "recommended modifications of the above principles for *temporary application under exceptional circumstances*" and the first statement is that "Such connections should not be permitted where the available public water supply or private fire protection supply is adequate for fire protection purposes."

## Changes Made at the Factories.

Of the seven factory plants affected by the order for disconnection, five were so rearranged and added to their fire service connections that it was unnecessary for them to do expensive work. In this connection it is also proper to add that the Hartford Water Department did its share toward reinforcing an already excellent system of distribution mains in this vicinity.

Several new gates were installed on the large feeders in order that smaller sections might be cut out without detriment to the service, additional hydrants were installed and a large new feeder main will be led directly into the district affected as soon as a right of way can be obtained under railroad tracks.

Two of the plants chose to install more elaborate works. One of them built an elevated tower of large capacity; and the other, the Underwood Typewriter Co., has nearly completed an elaborate and unique plant which is not duplicated, I think, in this country and is to be used, it is said, as a model for similar systems elsewhere. This plant will use river water only and will be without direct connection to the city supply.

The details of this plant were worked out by the Factory manager of the Underwood plant, Mr. Charles D. Rice, in connection with the Engineers of the Associated Factory Mutual Co. They appear to embrace the

majority of those features that insurance engineers deem requisite for a well protected plant.

Essentially this plant consists of a double-deck steel tank 30 ft. in diameter, and about 150 ft. high. The lower chamber will contain about 600 000 gal. of water which will be kept under pressure for immediate use. The upper chamber, holding about 100 000 gal. will be held in reserve as an emergency gravity supply.

At the base of the tank is a pump-house containing pumps, air compressors and other appurtenances. To guard against freezing special provisions have been made both to heat the water in the tanks, and in case of special necessity to cause complete circulation of the contents by pumping.

### Use of "F. M." Double-Check Valve.

In the recommendations of the Committee of the State Sanitary Engineers referred to above, and under Modifications for Temporary Application Under Exceptional Circumstances, the "committee is of the opinion that the most efficient and dependable device developed up to date (aside from the method described in principle No. 1 above, (quoted on page 11 herewith )is the check valve installation recommended by the Associated Factory Mutual Fire Insurance Companies of Boston, Mass."

The author of this paper fully concurs in this recommendation but would suggest the substitution of an all bronze body and valve for the present type, and similar to if not identical with the valve and its accompaniments built for the Hartford Manufacturers from the designs of Mr. Rice, as an example.

As a condition precedent to the installation of these connections for *temporary service only* and covering a stated period, agreement should be made to keep the water department fully informed of any defects that have appeared anywhere in the proper functioning of these valves, and changes in design should be reported both to the plant owner and to the Water Department.

Also both the plant owner and the insurance company should agree to notify the Water Department at once when the risk is withdrawn from the mutual company and placed with a stock company.

This is essential, as the stock companies, being neither so insistent on the use of these connections nor so impressed with their fire protection advantages over other means, either do not inspect them at all or as a matter of routine.

### Inspection by Water Department.

Inspection of these contrivances is absolutely necessary, and no water department official may shift the burden from his own shoulders to those of an insurance company and think to have immunity in case something goes wrong. Eternal vigilance here as every where else is the price of success.

At Hartford the inspection at the outset was supposed to be and they

were made conscientiously by the engineer in charge. Then came changes in personnel. For several years the presence of these valves was unknown to the engineer as he was not at that time given control of the maintenance work. When charge was assumed after some time the matter was casually brought to attention and, on looking into it, it was found that the inspections were then of the most perfunctory kind and were often omitted for long periods.

For the last two years of this installation the inspection by the Board's forces was made every week for pressure test, and once every three months the entire installation was taken apart and thoroughly cleaned and overhauled.

The results of this experience have firmly convinced the author that such inspection is absolutely necessary if even a reasonable assurance of safety is to be had.

Thousands of dollars are spent by water departments in sanitary patrol of water sheds, purchase of remote farms on the drainage area, and in all the refinements of the modern filter system, and then they often forget a through connection right at the consumer's door, trusting implicitly in a mechanical device to work perfectly and in a manner such as no other piece of human mechanism has ever been known to work.

## Responsibility.

If pollution of the water supply should obtain and an epidemic of typhoid fever ensue, the responsibility for death, disease and impairment of health must rest squarely on those officials who are in responsible charge of the water supply system.

Inspections by insurance employees, no matter how conscientiously performed, and the assurance of insurance engineers, no matter how eminent in the profession, can not relieve the local water man of his accountability to the people to furnish them with a safe water.

In the final analysis by the dependants of the lost one it makes very little difference whether death was due to typhoid fever or by burning. If pollution by the connection is very remote, as is the claim of some advocates of this system, so also is the danger of fire, and surely a water department should not be asked to take even the same chance with the health of the people that is deemed unwise as concerns property loss.

## Conclusions.

The PRINCIPLES enunciated at the conference of the State Sanitary Engineers, which is referred to above, are fully in accord with the conclusions that have been reached by me as a result of experience at Hartford and knowledge of similar conditions elsewhere.

I am heartily in agreement with them, because I believe them to be in accord with other provisions for conserving the public health, which are now deemed essential for the protection of a water supply used for domestic purposes.

## Discussion.

Mr. Frederic I. Winslow.* I do not think I have told this before, but about fifteen years ago the Town of Hyde Park, then a separate town, had a very serious epidemic of typhoid fever, which no one was able to account for. It went to two parts in the town, a mile apart or so.

About three years later this town became a part of Boston. I went out with some others and found that there were about six mills in town which had two supplies, one from the system in Hyde Park and another from Mother Brook, which is a connection between the Charles River and the Neponset River, and a very filthy stream. We found in one case that there had been a fire just before the epidemic had occurred, and without doubt that was the cause of the epidemic.

Along about that time Mr. Kunhardt, with his able corps of assistants, devised the double-check valve, two checks built into the same manhole. I have learned since that they found in one case where somebody left a pair of overalls in the pipe, and which stretched between the two valves, holding both open, and the water went back into the city system from the private one.

I am glad to heartily endorse the last statement of the speaker.

Mr. J. M. Diven.† I think about the only discussion on the proposition is that no such double connection should be allowed under any conditions, taking no chances whatever on double checks.

Mr. Harry A. Burnham.‡ It has been several years since this matter of Check Valves on private fire service connections has come before this Association, and this may be an opportune time to briefly review the situation as matter of record in the general field of fire protection by automatic sprinklers.

The automatic sprinkler has done more to reduce fire losses than any other single device. In New England these possibilities were quickly recognized in the early days and the efficiency of the fire extinguishing equipments in many communities was greatly increased by supplying these sprinklers direct from the city mains.

Soon the increase in values made possible by this improved protection brought about the need of a more nearly absolute continuity of supply and sometimes of a larger delivering capacity than was afforded by the average water-works system. This need was satisfied by the secondary supplies now found in practically all of the large manufacturing plants in the form of fire pumps, gravity tanks or private reservoirs. This secondary supply to the sprinkler systems brought about the need of check valves on both supplies in order to make available automatically the combined flow from both within the sprinkler system.

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* Division Engineer, Metropolitan District Commission.
† Secretary, American Water Works Association.
‡ Engineer, Factory Mutual Fire Insurance Co.

This race between values to be protected and water supplies to protect them with has been going on until it is now impossible to place a safe limit on the amount of water which may be needed to extinguish a fire in the large industrial plants of to-day.

This long period of development of fire protection engineering, covering now about forty years, has not been entirely free from accident incidental to the evolution of this science. Unexpected accidents have been comparatively few, however, and their lessons have been well learned. The problems presented by such accidents as the destruction of extensive properties due to inadequate water supply, sudden loss of a number of lives by fire due to the lack of sprinkler protection, an epidemic of sickness or loss of life by disease due to mingling of the water supplies, the starting of sweeping conflagrations due to lack of sprinkler protection, all have required careful consideration in their relation to each other.

In the face of these apparently conflicting problems the earnest endeavors of the water-works men to supply clean water suitable for domestic consumption and at the same time to maintain the high efficiency of the fire protection equipment have been greatly assisted by the development of better safeguards such as filters, chlorinating plants, private pumping plants, special check valves and other devices.

One device which has already done much to reconcile these conflicting problems is the simple swing check valve redesigned to secure thorough reliability in preventing leakage and installed two in series in accessible locations to encourage as excellent maintenance as any other part of the water-works system can receive.

A brief history of the development of this safeguard known as the Special F. M. double-check valve equipment was presented at a meeting of the Canadian Section of the American Water Works Association at Toronto, February, 1921, and appears in the May, 1921, number of the JOURNAL. That article covered the experience of the Associated Factory Mutual Fire Insurance Companies with this particular arrangement of special check valves.

Among the cases of public recognition given in that article are the following:

In April, 1918, the New York State Department of Health accepted this arrangement as a sufficient and satisfactory safeguard, with favorable comment on the Auburn, New York, installations.

In 1919, the State of New Hampshire revised its law relating to Emergency Intakes and Factory Connections to require the use of this safeguard.

In 1921, the Provincial Board of Health of Ontario issued regulations requiring this safeguard.

In July, 1917, the Water Department in Fall River made the ruling that all fire service connections should be protected with the double-check valve arrangement where a secondary supply is from a pump.

At a Conference of the State Sanitary Engineers, held in Boston, June, 1921, a report of the "Committee on Cross-Connections, By-Passes and Emergency Intakes on Public Water Supplies," was accepted and adopted in which the Committee "recognizes the relative degree of safety which can be provided by suitable check-valve installations on connections between public water supplies and a piping system used for fire protection only." "The Committee is cognizant of the fact that such connections may be proper and reasonable under certain conditions," and expresses "the opinion that the most efficient and dependable device developed up-to-date," except complete severance, "is the check-valve installation recommended by the Associated Factory Mutual Fire Insurance Companies of Boston, Mass."

At the San Francisco Meeting of the National Fire Protection Association in June, 1921, in the report of the Committee on Private Fire Supplies from Public Mains, Mr. E. V. French, Chairman, the following appeared among other topics which have been receiving the attention of that Committee for several years:

"Perhaps the most important development under the scope of the committee work is the continued excellent record of the double check-valve equipment above mentioned and described in the National Fire Protection Association proceedings of 1910. Over 500 such equipments are now in actual service in various parts of the country. These are periodically inspected internally and tested for tightness, and as far as is known no case of trouble in public water mains from leakage of these equipments has yet occurred. Information regarding this safeguard has been welcomed by many Water Works and Health Officials as the best solution available for problems in which the conservation of both life and property must be recognized."

From such information as comes to our Inspection Department in connection with our work on fire protection, we gather that the position of absolute prohibition of all cross-connections to unapproved supplies used for fire purposes has been taken by very few, if any, State Boards of Health.

The number of cities taking this position is extremely small, and specific rules or ordinances prohibiting this kind of connection are for the most part non-existent even in cities which are opposed to such connection on general principles.

The list of cities and states which require the special check-valve arrangement is very much larger than the list which actually prohibits their use.

The largest list by far is that of cities in which no definite position either for or against any fire service connection is taken, but which permit the installation of the Special type F. M. double-check valves as a desirable and necessary improvement over old conditions.

A recent count from our records shows these installations now number over 600 in 170 towns and cities in the United States and Canada, and as far as can be ascertained there has been no case of trouble from foreign water in the public mains due to the failure of any of these equipments.

It should be noted that the development of this safeguard together with regular inspections of its condition has made it possible for the large industrial plants of the country depending on the public supply for their fire protection through automatic sprinklers to retain the use which they have enjoyed for years of auxiliary fire pump supplies from large bodies of water, such as harbors, lakes and rivers, and this without any appreciable danger to the quality of the public supply.

As a means of conservation of life and property and avoidance of unnecessary duplication of large water supplies, the Special type F. M. double-check valve equipment in its present form is one of the most valuable contributions made in recent years to Water Works Engineering.

MR. L. H. KUNHARDT.* My friend, Mr. Winslow, did me the honor to mention my name as the one who introduced the special double-check valve. I came over here to-night as I heard of the program, and if I may be permitted to say a few words I should like to add that I think the essential thing in all this work of fire protection, engineering and water supply is coöperation. The owners of property need that coöperation; the waterworks people need the coöperation; the insurance companies need the coöperation. We need to work out a good plan, all of us, of something that is better.

Now, that brings me back to progress. We wish to progress in this work, not to go backward. Hartford was the first city, as Mr. Saville has said, to adopt the special double-check valves. They did a good thing. They did it on the basis of the recommendations of the Inspection Department of the Factory Mutual Insurance Companies. It was the finest thing that was put in at the time anywhere. Those early check-valves were an improvement on the first check valve, the ordinary commercial checks that were made. They were not perfect; we knew they were not perfect. The then Engineer of the Water Board in Hartford knew they were not perfect. The Company that made them had some difficulties in making all the improvements that were desired, but the check valves were put in because they were needed, and served their purpose admirably and well, and they protected the water connections.

Now, another point: If we could have these check valves on every connection — I am not speaking only of fire service connections, but every connection that has any supply from another source available or in use, and that condition exists in a good many cities and towns in the United States — I could mention dozens of them where business blocks, commercial buildings of all kinds, have double supplies of water; driven wells in country towns from which water is put in the same supply line that the city water

* Vice President and Chief Engineer, Boston Manufacturers Mutual Fire Insurance Co.

is going into — we would then have real security against pollution. Sometimes they do not have check valves of any kind or description. These are the most liable sources of contamination.

My friend, Mr. Winslow, mentioned Hyde Park. There were dozens of poor connections in that city other than those two or three in the mills. The mill connections were better protected than the others were, — there is no doubt about that. As soon as any water board, or engineer of the water works, in any way, shape or manner expresses a desire to have these old conditions changed, they are always ready to change them. I o not think there has been a single case where they have not been put in when they were asked for. The owners of property are glad to coöperate, and I am sure, as has been already stated, that you will find no lack of coöperation on the part of the fire insurance engineers in this country.

Now, about this reported leakage that occurred in Hartford, Conn.: We never heard of it until long after. It was in some of the old type check valves which were fixed over to make a fairly acceptable device. We never recorded in any of our tests a leakage of a double-check valve. Now, I say that advisedly. The double-check valve was put in for the very reason that one check valve might leak and the other one would not at the same time. That is what it is for. If one check had been enough they would not have put in two. There has never been a case of leakage back through the improved double-check valves, such as are approved and recommended.

The case cited at Lowell was so far from having anything to do with this proposition that we have before us to-day that it hardly needs to be mentioned. It was simply a case of a check valve designed many, many years ago, in a pipe which was not in use. The check valve had been taken out at one time when the canal was under repair, and laid out on the bank of the canal. It was a type of check valve that, when you turned it over upside down and put it back again, if you did not happen to put your hand inside and push the clapper down it might not go down, as I understand it, and when they put it in the pipe they left the clapper wide open. It was on an emergency connection. Now, the big fire came along when they needed all the water that they could get; 15 000 gallons of water per minute, I believe, were pumped into that fire. They needed every drop of it. They saved the mill. And they opened the gate valve to get the water from the city connection into the fire lines of the mill, and after the fire was over they did not get that gate valve closed quite as quickly as they might, and there was some water pumped back into the mains in Lowell, so far as is known. But it was through practically an open pipe. There was no real check valve on the pipe at the time it was pumping; just simply an open pipe back into the city main.

That is a condition, gentlemen, that exists in lots of places. You have open pipe connections in your cities and towns. They ought to be investigated. I wish you could have more of these special double-check services, rather than to stand back and say you won't admit them, and then allow

the present conditions to go on which are a serious detriment to the health of the community.

Now, be careful not to draw a wrong inference. Be sure and get all the facts. I just want to leave that thought in your minds before I sit down. I have in mind always that we want to progress, and here is a device distinctly better than anything else that has ever been installed in some of these big manufacturing plants, which need, not two, three or four thousand gal. of water a minute, but they need ten, fifteen or twenty thousand gal. of water a minute to do business with at a fire, and you can't find that supply ordinarily in a gravity system from 50 to 75 lbs. pressure, which is the normal pressure which exists, probably, in ordinary street mains of the cities and towns. Of course there are places like Fitchburg where they have very high pressure; also Worcester, and others that might be mentioned. But the ordinary pressure of 50 to 75 lbs. is pretty good for sprinklers and water supplied by hydrants until there is a big draft, and then you find the pressure falls off even with the mains of quite good size.

So I say, let us work out the problem of safeguarding these big industrial plants. In New Bedford there has been the finest kind of coöperation between the mills and the city water-works officials. When a mill is proposed the city lays down the big pipes and the mills put in the fire pumps 1 000 to 1 500 gal. pumps capacity per minute—not one or two but often three of four — making connections to the adjoining mills, so that there may be 10 or 12 of these pumps, in addition to all the water that the public water works can supply. They gladly fall in with the proposition and recognize the importance of the double service. Without this double service in Hartford the protection is now seriously curtailed.

Now, this double protection is none too adequate, if you get a sweeping fire at work in the vicinity of one of these plants. You have the same thing in Lowell, Lawrence, Manchester, and other big industrial centers in the country, and also in small communities. We need all the water that we can get and that it is possible to have at a high pressure for the proper fire protection and safeguarding of these plants. I think the property owners in a city or town have a right to this protection when they build these big plants on which the success of the community and its welfare depend. I thank you.

Mr. Diven. Unquestionably the double, or F. M., check valve is a great improvement over the old form, especially as the old ones were frequently buried in the street with no means of getting at them for examination. But even the most improved check valve cannot be relied on without careful, systematic and frequent inspection, and here the human element comes in — will they have such inspection? Or will they like many other water-works appliances be installed and then forgotten so long as they continue to work or seem to work all right.

It always seemed to the speaker that the mills and factories can have full protection without in the least endangering the domestic supply, this by installing entirely separate systems for the two sources of water supply, two systems with absolutely no physical connection. This would cost something, but is not the safety, the health and lives of the water users in a city worth the cost? It is urged that such dual supplies are not entirely safe, that the impure water lines may be tapped in the mills and used by employees in the mill or factory. True, but this would endanger the lives of only a small part of the community, would not contaminate the water in the mains from which the entire population draws its supply of drinking water.

The mills and factories are entitled to the fullest possible protection, it is good business to give it to them as the prosperity of the community depends on them largely. This applies to a water company as well as to a municipal plant, for the prosperity of the water company depends on that of the community.

MR. PATRICK GEAR.* The gentleman spoke about the improved double-check valve. What improvement is it over the old one that was made forty years ago? Who makes the improved check valves?

MR. BURNHAM. Those check valves are made by the Chapman Valve Company of Indian Orchard, Mass., the Fairbanks Company of Binghamton, N. Y., the Ludlow Valve Mfg. Co. of Troy N. Y., Pratt & Cady, of Hartford, Conn., the Grinnell Company, of Providence R. I., and Jenkins Brothers of Montreal.

MR. GEAR. I have bought all of them. I worked in a machine shop before becoming Superintendent of the Water Works. I took those check valves apart when they were new, and after that for twenty years, and got some of the new ones last year and took them apart to see where the improvement was, and I can't see it.

We have check valves that were installed in 1893, around the mill where I was working at that time,—a check valve set in a 12-in. line, and last year we had occasion to shut off that same line and the check valve was tight. This is not one of the new ones that was put in five or six years ago.

In one case the meter commenced running backwards. There was a check valve on the line and the clapper was up in the air. It was one of the new ones.

MR. DIVEN. While I rather condemn the use of the check valve, I have used them, and I will say that the ones I have seen lately have been a decided improvement, having a soft rubber face which makes a tight joint, and the addition of the second check valve makes it possible to make an inspection of both valves with very little trouble to see that they are tight.

MR. GEAR. If they can tell me where the brass clapper of this check valve is a quarter of an inch away from the cast iron, I will admit that they have improved it. It does not give a quarter of an inch clearance on the

* Superintendent Water Works, Holyoke, Mass.

sides. Corrosion occurs there, and it holds the clapper up. That is why they have to inspect and clean them every year.

Now, if they will make a check valve that will have a good clearance all around, and all brass, so much the better, as with good space on the sides they will close properly. But they have not made them that way yet.

MR. KUNHARDT. I would like to say to Mr. Gear, that if he will look at the installation at the American Thread Co., in Holyoke he will see valves there that have probably ¾-in. clearance between the iron and the brass. I think the installation will prove very pleasing to you, and certainly very much better than dozens and dozens of connections in your city. It is the best safeguard that has been installed in Holyoke for years, and is fine.

MR. SAVILLE. This Rice valve that I spoke of is an all bronze valve; the clapper seat and the housing,— everything is bronze. And aside from that, there is a pocket below the valve which is designed to catch gravel or anything of that kind, that may come through. The rubber that is put on for the facing was specially designed.

MR. Rice, previous to being Manager of the Underwood Typewriter Company, was Superintendent for a great many years of the old Columbia Bicycle Works, and as such he had a great deal of experience with rubber, and was much interested in developing a rubber gasket that would have many advantages over the rubber that you could get.

Another thing that comes up is the fact that no matter how good the inspection of the Factory Mutual people, inspecting the valves perhaps once or twice a month, or once or twice a year themselves, there is another serious defect. In Hartford one or two concerns that formerly had these check valves, and were at one time Factory Mutual risks, gave up their allegiance to that company. When the Factory Mutual Inspectors ceased to inspect those valves no notice was given the water department. I think that is true, is it not, Mr. Burnham?

MR. GEAR. I have been advocating for ten years both a check valve and a gate valve, that would have sufficient space between it and the cast iron.

MR. WINSLOW. We are all extremely gratified to see Mr. Kunhardt, Vice-President and Chief Engineer of the Manufacturers Mutual Ins. Co. present, and it is our loss that he is not yet a member of our Association.

No one appreciates more than the speaker the effective and splendid achievements of his company for the past thirty years, under the leadership of the late Edward Atkinson, Mr. Joseph P. Gray, and my friend, Mr. Kunhardt, with whom I used to clash while at City Hall, Boston, and I always realized, as we all must, that the underwriters and the water-works men must coöperate in the matter of fire and sanitary protection. The only point at issue — and this has not yet been fully answered — is whether the water-works man can afford to take the risk of possible contamination of the water supply, however remote that may appear to be. That is,

how can we be certain that both of those check valves will never be open at the same time?

Mr. Diven has anticipated me in suggesting that the double supply be permitted, but without physical connection, a method probably too expensive ordinarily; for one main point in getting mill owners to insure is to make the cost as low as is consistent with safety.

The solution may perhaps lie in some form of local purification — in the mill or factory — of the secondary source of supply, by chlorination, copper, or other chemicals.

MR. H. O. LACOUNT.* Being one of those that was in on this matter at the very start in Hartford, I have watched the progress and development there with a good deal of interest, and have listened to Mr. Saville's paper to-night giving the conclusion on the matter in Hartford with equal interest. It seems to me that while they have reached their conclusion there deliberately and definitely, that perhaps does not indicate the general verdict, because, as we have heard from Mr. Burnham's paper, there are a goodly number, and an increasing number of those who are giving recognition to this method of safeguarding the water supplies.

I have noted two things from my own observation: First, that the water departments are appreciating more and more the importance of safeguarding the public water; and secondly, that real headway is being made year after year in the use of this particular method of safeguarding the water, namely, the double checks of this special design.

Referring to Mr. Gear's remarks, I am very sure from what he said that he has not yet had the privilege of seeing one of these special valves, because they do have ¾-in. clearance around the clapper, between the clapper and the casing, with the direct object of furnishing more clearance than in the regular commercial check so that the clappers will not be hung up so easily by incrustation and corrosion of the casing itself.

Another feature of the valve I may say at this point, is the bronze clapper and the bronze clapper arm, as well as more distance between the bronze valve seat and the cast iron into which the ring is set. I am satisfied that there is a very definite improvement in these special checks over the so-called commercial checks, of which you will find so many thousands in use. And when you consider the care with which these are installed, and I am glad to say, the care that is taken of them after they are installed— we have improved conditions very much, and I think that is being appreciated by a good many of the water-works people.

Mr. Diven has brought up a point which I have had in mind, and that is the human element. There is the human element involved in the care and inspection of the valves, the valves being definitely designed to facilitate that inspection, making it as easy and convenient as possible to open them for inspection and cleaning. But the human element is not absent in a great many of the other water-works problems. You have a chlor-

*Engineer and Assistant Secretary Inspection Dept. Associated Factory Mutual Fire Ins. Co's.

ination plant. I have an idea that the human element enters very much in the chlorinating room. And you have a filter plant, and a great many times if not always there is a by-pass around the filter bed with a valve in the by-pass. It is put in there to operate under certain conditions. The human element may function wrongly there and leave the valve open at the wrong time.

So that we cannot eliminate the human element from our problem. It is here, and it is in a great many other places and conditions that the water department and everybody else must reckon with. So there is a real point in this coöperation that Mr. Kunhardt speaks about, and the appreciation of the value not only of property but of life. We may not gain so much as we think by going to the extreme point in any direction, if by doing that we cut down the protection which otherwise would have been provided. To discourage the installation of sprinklers by making it difficult to get a proper water supply, is to endanger the lives of those in the buildings not thus protected.

I think there are several sides to this question, which must be carefully considered before it can be regarded as settled. I am reminded that two years after this method was introduced in Hartford we had a meeting of the New England Water Works Association and this matter was discussed. It was somewhat of an experiment at that time, and we were speculating as to what would be the result. Six years later, in 1916, it came up again and was discussed at length. Now after another period of six years this subject is again on the program. Six years from now we may report more progress one way or the other. It is a matter which has received a great deal of attention and has a reasonable recognition already, and I think it is going good work.

MR. DIVEN. While it is true we can't eliminate the human element entirely, that is no reason why we should not eliminate it as far as possible. Personally I believe in the double-check valve if it is properly handled, and in any event it is a very great improvement over the old style buried and uninspected check valve.

MR. SAVILLE. There has been considerable said about coöperation and advancement. I fully agree with that, and I think we all do. We are all here for that purpose, — to see what is the other fellow's viewpoint and do as much as we can to work in harmony. It seemed to me, however, that coöperation and advancement might mean only approval of the double-check valve. So far as I know, none of the other insurance engineers except the Factory Mutual people are so insistent on this double-check valve proposition. All the other insurance engineers, the stock companies particularly, are fully satisfied with tanks of large capacity, or with cisterns into which city water can be brought through a large pipe, as large as required, and in case the auxiliary system breaks down the city water is available.

The only thing I can see in favor of the double-check valve system is the matter of cost of installation. I think in Hartford, with the manufacturers the question of the cost was not a consideration. Some of them have spent thousands of dollars in getting a supply that would conform with what was wanted by the Water Works. And on the other hand, a double-check valve system, just two checks and the little apparatus that goes with it, is very much cheaper than a good, big tank, or a cistern of large size, and if an insurance man can go to a manufacturer and say, "You can get secondary protection with check valve and cross-connections for $500 or $600 or $1 000, where you would have to pay $10 000 or $15 000 the other way," it is a big argument in his favor.

Now, two of the largest manufacturing plants in Hartford have had large underground cisterns. I am informed that these manufacturing plants are getting as low insurance rates as those that formerly had the double-check valves.

In discussing this matter at one time Prof. Whipple said that practical water-works men and health officials generally were opposed to this method of connecting up a supply, that there was undoubtedly some danger in it.

MR. DIVEN. Do you know of any plant having a double pipe system?

MR. SAVILLE. No, I do not.

MR. DIVEN. I have heard of one. Do you think the cost of that would be excessive, out of reason?

MR. SAVILLE. I should think it would, and also that there would be a great deal of danger inside the building of connecting up those pipes by the plumbers. For instance, I was talking with sombody who said they tested a system and it was thought all the valves were closed, but they could not seem to get the system dry. A thorough inspection was made and they found, unknown to the managers of the plant, that a plumber inside of the plant, in order to get some water to test out some plumbing had made a connection between a secondary supply tank and the regular system. There is an example, of the danger of two supplies.

## CONCLUSION OF DISCUSSION.

CALEB MILLS SAVILLE (*by letter*). The author is much pleased with the discussion which his paper has provoked, and is particularly gratified at the presence and participation of the Engineers of the Factory Mutual Insurance Company.

Such discussion cannot fail to make all of us see more clearly the veiwpoint of the other and so pave the way for that better understanding which reacts to the mutual advantage of the interests which we serve.

Mr. Winslow has performed a distinct service to the cause of pure water in putting on record the episode of the overalls stretched between the two check valves on the cross connection, and holding both of them open.

Hitherto statements refering to the danger of such a happening, usually have been flippantly brushed away, with the remark, that while anything might happen, such a case had not occured in the past, and with the double-check valves it was too remote for consideration.

An actual condition and not a theory is now described and is uncontroverted by the representatives of the Factory Mutual Insurance Companies, who are the particular sponsors of the type of fire protection, which uses the double check-valve connection.

The sequence of events is also interesting; the double-check valves on connections between the city supply and a foully polluted secondary source of water supply, and the use of the mill pumps for fire protection preceding the epidemic.

Whether or not the particular water which passed through the open double-check valves was responsible is immaterial. The fact remains that the protection relied upon for such an emergency did not work.

Such a condition would probably be considered as proof so reasonably presumptive in a court of law as to warrant the placing of the responsibility on the water department that knowingly allowed the existence of such an opportunity.

In the discussion of this paper and in articles elsewhere favoring the use of cross connections controlled by double-check valves, the efficacy of sprinkler systems has been interjected and considerably stressed, as if they and cross connections were inseparable.

While the value of sprinkler service for protection against fire must be fully acknowledged by all well informed persons, it has not been made clear what is its place in a discussion of the question as to whether or not a check valve controlled connection is or is not desirable between an adequate city water supply and a polluted source.

The principal value of sprinkler service is *prevention* of fire by extinguishing a blaze in its incipiency and *before* it can spread. For this purpose comparatively limited amounts of water are required.

Insurance engineers generally place little value on sprinkler service *after* a conflagration has gained headway; and the opening of hundreds of sprinkler heads, with their continuous and promiscuous discharge, after a building has been gutted by fire, may so reduce pressure in street mains as to seriously interfere with proper fighting directed by brain rather than by chance.

Experience at the Salem, Mass., holocaust 1914,* offers unimpeachable testimony supporting this assertion.

Unless there is some peculiar virtue in sewage for fire extinguishment it would seem that an amount of water adequate for sprinkler purposes might better be had from an elevated tank of proper size or from an underground cistern. Into either of these city water in any quantity desired can be run without dangerous connection with a disease ladened water course.

* Page 97 Jour. N.E.W.W.A. Vol. XXIX, 1915.

I am led to lay particular emphasis on this point, because so far as I know, no sound argument has ever been presented by advocates of the double-checked cross-connection in support of that means of serving a sprinkler system as against an adequate supply of water from a cistern or tank of proper size.

Proper size would be defined as that size which a majority of experienced insurance engineers would consider reasonable.

As to yard hydrants that is a different matter and it seems to be clearly evident that increase in efficiency is best served by a separate system into which a secondary supply can be pumped from a source of unlimited capacity.

Even in this case, however, the practical need of an automatic connection with the city water mains has not so far as I know been demonstrated in fact.

The installation of such safeguards as filters, sterilizing plants, and sanitary control of water sheds at the entrance to the distribution system is all for naught, if inside that system there is a connection with a public sewer, under automatic control, which in time of remote emergency may fail to function properly.

Because filters may be by-passed, sterilizing apparatus get out of order, and chance pollution invade a water storage reservoir, there are no arguments for knowingly allowing connections which at best can be made to operate only by constant attention.

Modern sanitary safeguards aim to protect public health by the most efficient known means. The fact, that being of human contrivance, the methods are not always infalliable, certainly offers no excuse for consciously adding one more opportunity for contaminating a water supply.

The specious reasoning, that makes use of such fallacious and subtle arguments, indicates a tendency to sophistry that should serve to discredit it in the minds of thinking persons.

As to the reference of Mr. Burnham to the approval of State Boards of Health: —

Replies of many State Departments of Health from all over the country in answer to a questionaire sent out by the Hartford Water Department in reference to this matter, and particularly including those that allow the use of the double-check connection, indicate very guarded approval, and none of them seem to place implicit confidence in them. "They are better than nothing." These answers are on file.

In some cases limited approval has been given, in others peculiar circumstances were considered, and in others matters of "expediency" or of "public policy," appeared to control.

The *complete* statement of the principles enunciated at the State Sanitary Engineers Conference at Boston, refered to by Mr. Burnham and mentioned by the author of this paper on page 12 of the text, is added to the paper as Appendix A.

As to the statement "that so far as is known no case of trouble in public water mains from leakage of this equipment has yet occured," it seems unnecessary to comment or to trace the exact path of the particular disease germ when such cases as the Hyde Park overall incident and the leaking check valves at Hartford are of record.

The statement that "so far as can be ascertained there has been no case of trouble from foreign water in the public mains due to failure of any of these equipment" seems a perfectly safe one to make, but difficult of substantial proof either for or against. It is, however, no conclusive argument because in Hartford and probably elsewhere most of these connections have never been subjected to practical service conditions. In the one case that we have of record, however, Hyde Park, there was probable evidence that they did fail to function when the call came.

As indicative of the general attitude of fire insurance engineers, a statement of Mr. Geo. W. Booth, Chief Engineer of the National Board of Fire Underwriters, is quoted (*Engineering News—Record*, June 17, 1920):—

"Insurance standards require, for complete reliability two independent sources of supply, and the plant management, or the municipal authorities may, and often do, use one source which is unsafe or questionable from a sanitary standpoint, for the reason that it is a cheaper or easier one.

"The engineers of the National Board of Fire Underwriters do not, and we believe other engineers should not, favor such connections, but it is not possible, without charge of discrimination, to refuse credit for them as emergency sources.

"It is, however, standard practice with many of the insurance bureaus to recommend secondary sources of supply which will be safe, as for instance a storage reservoir."

Mr. Burnham speaks for the installation of the double-check valve installation as a means of avoiding unnecessary duplication of large water supplies. If a municipality knowingly and deliberately balances dangers of pollution of its water supply against the cost of proper fire protection, including both water system and public fire department, there is no argument. The city should have what it desires, but its authorities cannot shift responsibility. They, and not the insurance company, are to blame in case of trouble.

If, however, a city is willing, as Hartford has ever been, not to count expense in keeping its water system up to the best modern standards and in providing a fire department which is recognized by authorities as "equal to the very best in the world" it would appear from the antecedent proposition of Mr. Burnham that double-check valve, cross-connections were unnecessary.

I am glad that Mr. Kunhardt has spoken of coöperation, as it gives me a chance to tell what Hartford's Board of Water Commissioners did for reinforcement of a water supply system in the factory district, although it was previously amply adequate.

In order to segregate smaller districts, in case of a large fire, with broken mains and factory standpipes bleeding the system, two 24-in. gates and 6 gates on 10 and 12 in. lines were installed; four new hydrants were located; permission was given for two new fire connections of larger

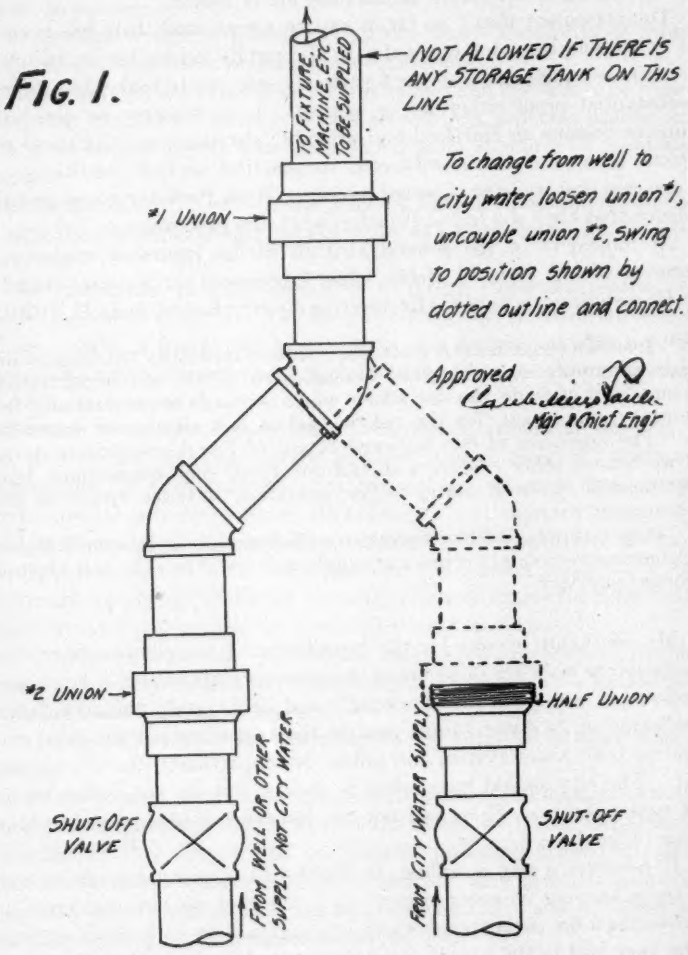
FIG. 1.
TO FIXTURE, MACHINE, ETC TO BE SUPPLIED
NOT ALLOWED IF THERE IS ANY STORAGE TANK ON THIS LINE
To change from well to city water loosen union *1, uncouple union *2, swing to position shown by dotted outline and connect.
Approved
Mgr & Chief Engr
*1 UNION
*2 UNION
HALF UNION
SHUT-OFF VALVE
SHUT-OFF VALVE
FROM WELL OR OTHER SUPPLY NOT CITY WATER
FROM CITY WATER SUPPLY

size than usually allowed, and promise was made to install a 16-in. connection about 1 100 ft. long as soon as right of way is given by the city, making an entirely new connection into the district.

No drastic steps were taken in the enforcement of the order for disconnection, and the factory owners were given their own time to complete changes in their works. It is proper to state, however, that on their part

the factory managers made every effort to comply quickly with the desire of the Board.

For manufacturing purposes a connection was deviced (Fig. 1) which while allowing full use of a private supply was easily manipulated to supply city water in case of need, and yet provide absolute safety by complete severance. No stand-by charge is made for this service.

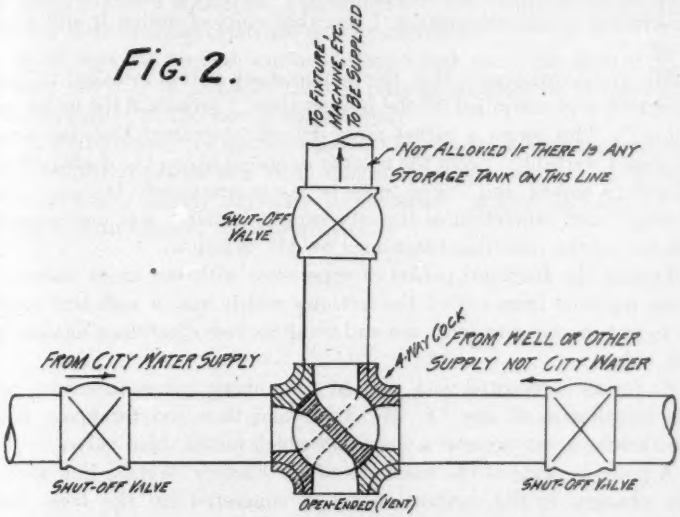
Fig. 2.
To Fixture, Machine Etc. To Be Supplied
Not Allowed If There Is Any Storage Tank On This Line
Shut-Off Valve
4-Way Cock
From Well or Other Supply Not City Water
From City Water Supply
Shut-Off Valve
Shut-Off Valve
Open-Ended (Vent)

Dotted lines show position of cock when drawing City Water. Flow of water is controlled by shut-off valves. Purpose of 4-way cock is to guide the water in the manner desired and at the same time to furnish a vent for leakage of foreign water by the cock when foreign water is being used and to prevent the building up of any pressure of foreign water against the cock when city water is being used.

Approved C. H. Lawrence
M'g'r. & Chief Engr.

Another device (Fig. 2) was proposed, which also seemed to afford absolute safety and yet be ready for use when needed. This was not approved by the Board because of its desire to have complete physical separation of its water system from that from any other source.

As to progress, also urged by Mr. Kunhardt, it seems to the author that progress and coöperation between the public health and the fire insurance interests must work toward that which is advantageous to both, that is what is ordinarily meant — the getting together for mutual advantage. There is no coöperation when the giving is all on one side.

Open-minded consideration of standard means for furnishing the secondary supply, ample service from the city system, large-sized mains, abundant hydrants, and a disposition to consider the faults in both the private and the public demands in an impartial manner, seem to me to be among the guide posts along the path of coöperation in this matter.

If, however, the first regard of some of the insurance interests is in getting maximum protection at lowest cost, with public health a secondary consideration in this coöperation, I fear that unity of action is still a long way off.

Mr. Kunhardt argues that the double-check valves installed in Hartford in 1908 and continued till the present time, " protected the water connections." This seems a rather more definite statement than the actual facts would warrant. From the records as stated above the double checks at Hartford leaked, and leaked more or less continuously, both at a time and singly, and protection of the city supply certainly was not enhanced by danger of the condition mentioned by Mr. Winslow.

During the Hartford period of experience with the check valves, no fire was reported from any of the factories which was of sufficient magnitude to put the fire pumps in use and bring service conditions against the check valves.

So far as is reported with the old style check valves in service prior to the installation of the " F. M." type, and that, too, for many years, there likewise never occured a condition which tested these valves.

A point is made of the readiness of the Factory Mutual Engineers to make changes in the connection when suggested by the local water department.

Water-works officials are often not so well informed as are the insurance engineers of the failures of protective devices, and in some cases absolute dependence is placed on the periodic inspection of the engineers of the insurance company.

It appears that the spirit of coöperation which is urged should at once take up with water departments any apparent failure of these connections, advise of their improvement and insist to mill owners that changes be made for the protection of health as well as for protection against fire.

At Hartford the Factory Mutual engineers now say that the valves were of an older type, but no notification was given that a better design was even then being installed at Holyoke, only a short distance away.

An outstanding feature of Mr. Gear's discussion is the fact that the insurance company engineers apparently found some radical defect in one or more of the check valves at Holyoke, but did not think it necessary or desirable to inform the water department that they were making changes which affected a connection between the city supply and a polluted secondary supply.

As is generally understood, a prime requisite of coöperation would seem to be a conference, if something is to be done which affects interests of two or more persons.

The Lowell check valve that failed is said to have been the best of its kind, and money was not spared in its construction; the " F. M." valves installed in Hartford in 1908 were claimed to be the best of their kind and proposed as a substitute and equivalent for complete separation of services; both of these types are now condemned.

How soon the present improved design may go to the discard no one can say; but it is to be hoped that its passing may not be brought about by a duplication of the Lowell catastrophe.

As stated above the author believes that progress in the safeguarding of big industrial plants is a vital obligation on the city, which demands adequate water mains, duplicate if necessary, proper pressure for fire fighting and an efficient fire department.

## "APPENDIX A."

## CONCLUSIONS OF THE COMMITTEE ON CROSS-CONNECTIONS. BY-PASSES AND EMERGENCY INTAKES ON PUBLIC WATER SUPPLIES.*

The Comittee on Cross-Connection By-Passes and Emergency Intakes on Public Water Supplies, after several meetings and full consideration, recommends the adoption of the following definitions and principles:

### A. Cross-Connections.

*Definition:* — A "cross-connection" is a physical arrangement whereby a public water supply system is connected with another water supply system either public or private, in such a manner that a flow of water into such public water supply system from such other water supply system is possible.

*Principle No. 1.* No cross-connections should be established or maintained between the public water supply system and any other water supply system, private or public, unless both water supplies are of safe sanitary quality and both supplies and the connection thereof have received the approval of the State Health Department.

*Principle No. 2.* In cases where it is necessary or advisable to supplement an impure private water supply with the public water supply distributed in the same piping system, the public supply must be made available by delivering it into a cistern, suction well or elevated tank, at an elevation above the high water line of such cistern, suction well or tank.

*Recommended Modification of above principles for temporary application under exceptional circumstances.*

While the Committee is of the opinion that absolute safety demands such complete separation of the public water supply system from other water supply systems delivering impure water, the Committee recognizes the relative degree of safety which can be provided by suitable check-valve installations on connections between a public water supply and a piping system used for fire protection only.

The Committee is cognizant of the fact that such connections may be proper and reasonable under certain conditions, and desires to express the following requirements which should be met in making and maintaining such installations:

1. Such connections should not be permitted where the available public water supply or private fire protection supply is adequate for fire protection purposes.

* From the Report of the Committee on Cross-Connections, By-Passes and Emergency Intakes on Public Water Supplies." Conference of State Sanitary Engineers, Boston, Mass., June 1, 1921.

2. That the fire protection piping system shall not be connected with any other piping system upon or within the property served, and that there shall be no outlet from such fire protection piping system except through sprinkler head, fire plugs and hose connections. This requirement is intended to prevent a flow through check valves except at times when a sprinkler head, fire plug or hose connection is open.

3. The cross-connection shall be equipped with such devices as can most effectually prevent an inflow of water from the fire protection system to the public water supply system.

4. The Committee is of the opinion that the most efficient and dependable device developed up-to-date (aside from the method described in principle No. 2 above) is the check-valve installation recommended by the Associated Factory Mutual Fire Insurance Companies of Boston, Mass., consisting of two gate valves with indicator posts, two check valves of the Factory Mutual type, with drip cocks and gages for testing, an alarm valve equipped with a recording pressure gage, a by-pass meter around the alarm valve, all to be placed in a vault of water-tight construction accessible to ready inspection.

5. A systematic test inspection of the cross-connection, including periodic examination of the interior of the check valves, by the Department in charge of the public water supply system must be provided, without which inspections the installations of the cross-connection would be a highly dangerous health menace. The inspection must therefore be made reliable, thorough and responsible.

6. The Committee views as a self-evident requirement that in every case where a cross-connection is being considered for action, a thorough investigation will be made as to local conditions and as to the necessity and advisability of the cross-connection, and that the local municipal officials will be made fully acquainted with the circumstances and given due opportunity for presenting their opinions.

# SOME COURT DECISIONS INCIDENT TO THE PURCHASE OF THE BRAINTREE WATER SUPPLY CO.

BY HENRY A. SYMONDS.*

[*September 13, 1922.*]

The subject of this paper is now ancient history, but there are some points relative to the legal phases of the controversy which I will describe that may be of interest and undoubtedly remain as strong precedents for future cases of this nature.

The case mentioned is that of the purchase of the water works of the Braintree Water Supply Co. by the Town of Braintree in the 80's.

To make clear the points to be brought out in this paper, it may be well to here state them briefly. The Court rulings seem to establish the following:

*First:* That a municipality, acting under the common form of charter rights relative to the purchase of a public utility, and having once taken a formal vote to purchase, cannot subsequently rescind such a vote.

*Second:* That water cannot legally be drawn for municipal or other purposes from an underground supply having as a source, as part of its supply, a pond or stream in which no right of the municipality or company exists.

*Third:* That selectmen of towns have regulatory supervision only over streets, but the rights of such a Board are not sufficient to prevent a public utility acting upon such streets in accordance with its charter.

*Fourth:* Cash or other payments for stock are not necessary to the legal organization of a public utility with Legislative charter.

In 1885 the town of Braintree had become somewhat interested in the question of a water supply and obtained an Enabling Act jointly with the towns of Randolph and Holbrook, in which right was given to each to act independently of the other in establishing water supplies, and taking a portion of the water from Great Pond in the towns of Braintree and Randolph, also the customary right to take water from other sources.

In general, the provisions of this act were the usual ones that had been incorporated into Enabling Acts up to this date, with a few minor exceptions. The Town Enabling Act was accepted, but no further action was taken to install a water supply, and in 1886 the Legislature passed an act incorporating the Braintree Water Supply Co., under the usual terms, but giving the right to take water from Great Pond contingent upon permission of the Town of Braintree. Section 10 of this Act is as follows:

"The said Town of Braintree shall have the right to, at any time during the continuance of the charter hereby granted, purchase the fran-

* Consulting Engineer, Boston, Mass.

chise, corporate property and all the rights and privileges of said corporation at a price which may be mutually agreed upon between said corporation and the said Town, and the said corporation is authorized to make sale of the same to said Town. In case said corporation and said Town are unable to agree, then the compensation to be paid shall be determined by three commissioners to be appointed by the Supreme Judicial Court upon application by either party and notice to the other, whose award, when accepted, by said Court, shall be binding upon all parties. This authority to purchase said franchise and property is granted on condition that the same is assented to by said Town by a two-thirds vote of the voters present and voting thereon at any meeting called for that purpose."

This company began constructing a water works plant during the summer of 1886, completing a filter gallery on the shore of Little Pond in Braintree, laying pipe lines and supplying the Old Colony R. R. Shops.

During the Fall of 1886, a strong sentiment developed in favor of town ownership of the water works. At a meeting called on January 12, 1887, the Town voted to purchase the corporate property, rights and franchise of the Braintree Water Supply Co. At an adjournment of this meeting, a committee was appointed who were to confer with the officers of the water company, examine their books, and get from them a price at which they would agree to sell their holdings.

Shortly after this meeting, the committee met the officers of the water company as directed and requested them to state the price for which they would sell their property. The company was not ready to fix a price but offered to submit a written proposition, which was done in a communication dated February 8, 1887, offering to sell their franchise and corporate property for $23,000, with the provision that the Town assume all obligations of the company.

It was further stated that the company had, previous to the meeting of January 12 and before any obligation of any character had been assumed by the company, offered to sell to the Town its franchise. This offer was not accepted and the company had subsequently (in 1886) made a contract to build a complete system of water works, the cost not having been fully determined, but to be contingent upon the development of the work. An estimate was made of $129 000 which, added to the price for the franchise, was estimated to make the total cost to the Town about $150 000.

In the last paragraph the company reserved the right to "withdraw this proposition after 30 days from date thereto unless the same shall have been accepted by the Town."

The committee submitted a report to the Town at a meeting called on February 23, 1887, but the Town failed to take action except to accept the report. On March 1, a notice was sent to the Town by the company that they would apply to the Supreme Judicial Court for the appointment of commissioners to determine the amount to be paid the company by the Town, unless prompt action was taken by the Town. On March 9 such a petition was filed.

The men actively interested and acting for the Town and for the company, were of unusual capacity, representing the highest professional and business standards.

It is evident that, following the report of the Committee, the Town, having learned that the company had made a contract to build a complete system of water works, and feeling that such a system, built under a contract which they were to inherit, might not be in accordance with the plant they wished to build, had gradually become dissatisfied with the arrangements and decided that it was wise for the Town to withdraw.

At a town meeting called on March 10, 1887, it was voted to rescind its vote of January 12 to purchase the property of the water supply company, and it was further voted to proceed to build water works under the Act of 1885, the Town Enabling Act. On March 23, 1887, a Board of Water Commissioners was elected. On May 26 of the same year the petition for the appointment of commissioners was heard before Judge Walbridge A. Field of the Supreme Judicial Court with counsel for petitioners, Hon. Robert M. Morse, Jr., and Marcus Morton. For the respondents appeared the Hon. Edward Avery and the Hon. Benjamin F. Butler. Such an array of legal talent insured a most interesting hearing and there followed a trial which has probably few equals in cases of this kind.

The testimony in this case covers approximately 240 pages and only a few points can be touched in this paper.

Mr. Morse, for the petitioners, presented the case of the company, claiming that the Town had, by its vote of January 12, legally purchased the water company franchise and property and could not withdraw from this act, and, therefore, that the vote of March 10 was void. The attorneys for the respondents claimed that the vote of January 12 was not a vote to complete the transaction; that it was only the first move toward buying the works; that the phrase "that the Town would purchase" intended to imply that a contract would be completed if satisfactory terms were made. They stated that the Town had no knowledge of the contract to build works and, therefore, could not be legally holden by a vote of this nature. They even argued that the organization of the company was not a legal one; that, as the stock which had been subscribed for had not been paid for in cash, the company had no standing. It also claimed, that, as the company had turned over to the contractors as payment for completing the water works all of the stock and bonds of the company, the company had nothing to sell and, therefore, no such purchase could be made. It was argued by Mr. Avery that as the company had disposed of its stock and bonds that the Town could not interfere with the rights of outside holders of these securities.

Mr. Morse gave a very convincing closing argument to prove that the Town, having once voted to purchase the works under the provisions of the Act, could not withdraw from that position.

After considering the evidence and testimony, Judge Field did not allow the petition, and a ruling to this effect was given in June, 1887.

Although the Town had appointed a Board of Water Commissioners, and voted to authorize an issue of $100 000 in bonds to build separate works, no action had been taken previous to the decision of Judge Field.

On September 8, 1887, the water commissioners entered into a contract with a local firm, to complete a system of water works having the source in Great Pond, and work was subsequently strated upon this second system of water supply for the Town of Braintree. The water company, however, continued to operate, through its contractors, in constructing a system from the Little Pond source.

The next move was by the Town, through its Board of Selectmen, who gave formal notice to the contractors to cease delivering pipe and digging up the streets of Braintree for the purpose of laying pipe.

The contractors, believing they had legal rights to proceed, refused to discontinue work.

The Town then attempted to bring an injunction restraining them from operating in its streets.

A verbal ruling was given by Judge Charles Allen, of the Supreme Court, to the effect that the company was operating within its rights and could not be enjoined to prevent the exercise of its charter rights; that the authority given the Selectmen by the charter must be considered regulatory only.

Meantime an appeal from the ruling of Judge Field had been taken to the Full Bench of the Supreme Court, and on April 7, 1888, Judge Knowlton of that court rendered a final decision reversing the ruling of Judge Field. The substance of this decision is perhaps the point to be brought out in this paper, and I would like to quote a few of the paragraphs which seem of interest:

"The fundamental question in the case is, what were the rights and obligations of the respective parties under this section? An important part of the chapter relates to the powers and duties of the Town in managing the business of furnishing water, in case it should purchase the property and franchise of the petitioner; and the intention of the Legislature to give the Town the right to take this business in charge is manifest. The authority conferred was not the power to take property by an exercise of the 'right of eminent domain,' but it was somewhat analogous to it. It was an authority to the Town to determine absolutely by its own act, in the form of a two-thirds vote, at any time during the continuance of the charter, that the petitioner's property and franchise should become its own. The statute calls it 'a right to purchase' and seems to contemplate a transfer of title in the form of a sale, and the execution of some proper instrument as evidence of the transfer. For, if the Town should vote to purchase, after the petitioner's works had been constructed, there might be a great variety of property, real and personal, to be transferred, and no way is pointed out, in which the Town could obtain and preserve in convenient form the evidence of its title except through an instrument of sale.

"But, as a preliminary to fixing the rights of both parties, — of one to have the franchise and property, and the other to have the pay for it, — no writing and no negotiation was required; nothing but the vote of the Town declaring its determination. The Legislature conferred upon the Company the corporate franchise, with a condition annexed in favor of the Town. By accepting its charter, the corporation impliedly agreed to sell whenever the Town by vote should decide to buy. The legal relation of the parties was as if the corporation had made in writing a continuing offer to sell, at a price to be subsequently agreed upon by the parties, and in default of agreement to be fixed by commissioners.

"The vote of the Town to buy was an acceptance of the offer which completed the contract. The rights of the parties were then the same as if both had signed an executory contract binding one to sell and the other to buy, at a price to be agreed upon between them, or determined under the statute. Neither party could then defeat the right of the other to have the contract executed. By the terms of the statute, it was to be specifically performed. The Town might, if it had chosen, have declined to avail itself of the offer held out to it, under this statute, to purchase at a price to be afterwards fixed, and have voted under the authority of Pub. Stat. Chap. 27, sect. 27, and perhaps of this statute also, to negotiate with the corporation in reference to making a purchase if a satisfactory price could be agreed upon. It was plainly an exercise of the Town's legal right to buy at a price to be subsequently fixed."

"It is argued that the petitioner entered into a contract with Wheeler & Parks which prevented the vote from taking effect, but this argument is not well founded. The corporation might go on under its charter and make any proper contracts for the construction of its works and for conducting its business. No contract that it might make could deprive the Town of the right to purchase its property and franchise under the statute, or prevent the appointment of commissioners to determine the price to be paid. Any contract in terms inconsistent with the exercise of that right would be contrary to the statute, and void as against the Town. Any contract properly made in carrying on its business would be binding upon it. Section 9 of this charter authorized a mortgage of its franchise and property under certain limitations, but it does not appear that the mortgage named in the vote of September 15, 1888, and stipulated for in the contract of October 30, 1886, was ever made. The respondent contends that the corporation was never so organized as to be capable of selling its franchise or property, or of maintaining this petition. It must be remembered that this is a corporation created by a charter, and that neither payment for its capital stock, nor even subscription for all of it by individuals was a necessary preliminary to organization or to the transaction of business by it.

"The provisions of Pub. Stat. Chap. 105, Sect. 9, in relation to organization are merely directory, and are intended to secure to all members of a corporation their right to participate in its proceedings. If all the members consent to an organization which disregards the statute requirements as to notice, the organization is valid. Newcomb v. Reed, 12 Allen, 362; Walworth v. Brackett, 98 Mass. 98. The proof of the Act of Incorporation, of the action under it and of the dealings of the respondent with the petitioner, as such corporation, is presumptive evidence that the corporation was legally organized, and is sufficient for the maintenance of a petition in the corporate name. Bank v. Silk Co., 3 Mass. 282; Society v. Davis, Id. 133; Institution v. Harding, 11 Cush. 285; Insurance Co. v. Jesser, 5 Allen 448; Toppings v. Bickford, 4 Allen 120; Hawes v. Petroleum Co., 101

Mass. 385. The neglect of the Town to act upon the report of its committee containing the offer of the petitioner shows that the parties were unable to agree upon the compensation to be paid. Indeed, bringing this petition without evidence of negotiation, or attempts to negotiate, would be enough to satisfy the requirements of the statute in regard to that. Burt v. Brigham, 117 Mass. 307; Aetna Mills v. Waltham, 128 Mass. 422.

"Upon facts agreed, we think the allegations of the petition are established, and that commissioners should be appointed to determine the compensation to be paid by the respondent for the franchise and property of the petitioner. Ordered accordingly."

Following this decision, three commissioners were appointed, Judge John Powell, Darwin E. Ware and Moses Williams, Jr. The firm of local contractors who had built part of the Town works from Great Pond, brought claim against the Town for the work done and for anticipated profits, which was eventually settled by the Town.

As the filter gallery of the company's plant was close to the shore of Little Pond, the proprietors of mills on Monatiquot River petitioned the Supreme Court for an injunction to restrain the Braintree Water Supply Co. from taking the water of Little Pond. There were many interesting points brought up in the ruling of Judge Devens, of which the following contain the substance:

"The plaintiffs have used, under this authority, Little Pond as a reservoir, maintaining a dam at its outlet, where they own a parcel of land, whereby the water is retained until they have need of, and have occasion to draw off the same for the use of their mills, about six weeks in the year. The water is of great importance to them. If deprived of it, it may be necessary to stop some of their mills during a portion of the summer, and its diminution would seriously injure them all. Before the shore of Little Pond and near it, the defendant has constructed and maintains a filter gallery, from which it draws water with which it supplies its customers, and it is found that a substantial part, much more than half of the water in the gallery, filters from the pond, and that all, or nearly all, of the remainder would have reached the pond if not intercepted by the gallery. The use of the water during the past season by the defendants diminished the quantity in use for the mills. It also appears that if the amount of water used by the defendants is increased a larger proportion will come from the pond than from the land side, and the larger the amount of water used the greater will be this proportion. It is the contention of the defendant that the word 'springs' and 'waters connected therewith' are sufficiently comprehensive to include this pond, and that the act gave the right to take any water in the Town of Braintree, with the exception of Monatiquot Springs, which are not within the watershed of Little Pond, leaving to the plaintiffs a statutory right to compensation therefor, if they are entitled to any.

"But a pond is quite distinguishable from the various sources of supply, whether those are the surface waters, or brooks, or springs which create and maintain it. When so large as to have become what is known as a great pond it is subject to all the rights which the public possess or which the Legislature may be entitled to grant therein. The fact that the Act, under which the defendant claims, specifies Great Pond, so-called, as one which may be taken, strongly indicates that the right to take other ponds of that

class was not inferred. 'Springs' as the word is generally used, means the sources of supply issuing from the earth as found therein by digging or otherwise opening it, and 'the waters connected therewith' are those flowing therefrom or bubbling up therewith.

"While in Peck v. Clark, 142 Mass. 446, it was held that a stream of water, whose sources were on the adjoining land, might pass as a spring, it was so because the evidence showed that this was what the parties had sought to describe, and that the word had been used by them with reference thereto.

"If the water cannot be taken directly from Little Pond, it cannot be drawn therefrom by percolation. Hart v. Jamaica Aqueduct Corporation, 133 Mass. 488.

"The process by which the defendant obtains it is unimportant, and the method is one well-known and often found convenient. It has often been held to be as complete a taking of water as the withdrawal of it by pipes. Brookline v. McIntosh, 133 Mass. 215; Cowbroy v. Woodman, 130 Mass. 410.

"The filter gallery, as described, is not intended to gather alone the water naturally upon or belonging to the land where it is, but being located on the shore the waters of the pond percolate through the intervening earth and fill it. Nor does the fact that the defendant has purchased the land bounding upon the pond, authorize it to withdraw the waters thereof for their purposes as a corporation. Potter v. Howe, 141 Mass. 357.

"The plaintiff claims not only the right to the entire waters of the pond, but to those within its watershed, and urges that the proper construction of defendant's charter does not authorize it to construct any well or gallery which would intercept any water which otherwise would reach the pond, and that the defendant's right to take any springs is thus limited to those which are outside the watershed of this pond. This would be to construe defendant's charter too narrowly. The corporation is created for an important public purpose. It is authorized to 'take the waters of any springs or artesian or driven wells within the Town of Braintree', etc. The reason why we hold that this does not authorize the taking of the waters of Little Pond is, that the water thus collected is known by a different description from the waters which are its sources of supply, but it is contemplated that these may be taken. It is the right of each land owner to dig wells on his own premises, even if he thereby intercepts the flow of water to the neighbor's well or streams. Greenleaf v. Francis, 18 Pick. 117; Chase v. Silverstone, 62 Maine, 172.

"If all that the defendant had done was to construct a gallery which would reach the underground sources of supply alone, which were on the land when it was constructed, or even the surface water which might flow thereon, quite a different case would be presented from that which is here found. When the defendant constructed a gallery, the principal use of which was to take water from the pond, which it had no right to do, even if it thereby obtained some water which it might lawfully have appropriated, it had not fairly exercised the authority with which it was intrusted, and independent of any right which it might have to take the springs, the plaintiffs could fairly ask that it be enjoined from maintaining it. If the defendant has no right to take the waters of Little Pond, it is necessary to inquire whether the plaintiffs have any such right therein that they may ask protection of the Court in the enjoyment thereof, as against the defendant who is supplying water to certain inhabitants for domestic uses, and it is the contention of the defendant that the plaintiffs had a most revocable license to use and

enjoy certain public property which the State might terminate at any time at its pleasure." Wattuppa Reservoir Company v. Fall River, 147 Mass. 548.

"The plaintiffs have directly maintained that their dams have had the exclusive control and use of the waters of this pond for sixty-five years; have erected valuable mills which have been of incidental benefit to the community, and have had the advantage, during that time, of the water for their mills. Without considering whether this, under all the circumstances, would give more or greater rights, it is sufficient at least to entitle them to the enjoyment thereof as against a corporation acting *ultra vires* in removing its water. Nor is it any answer to say that defendant is doing a valuable public work in supplying the citizens of Braintree with this water. This right to take the water lawfully collected and enjoyed by others is still limited to that which is conferred by its charter."

. . . . . .

"Upon the whole case we are of opinion that the plaintiff was entitled to an injunction forbidding the defendant withdrawing the water from Little Pond, and from using the gallery constructed by them, unless it can be so altered that it may be used without producing this result."

The company made final settlement with the mill owners for $20 500.

On March 13, 1891, the commissioners fixed the amount to be paid from the Town of Braintree to the Braintree Water Supply Company as $159 610.44.

I am pleased to mention that the Hon. James T. Stevens, who so faithfully represented the Town through much of the troublesome time of acquiring the water works, has been since 1902, and is to-day, a member of this Association. He has continued since the construction of the works as chairman of the Board of Commissioners, and has just passed his 83rd birthday. While somewhat physically infirm, he is still at the height of his mental capacity, an alert, powerful, courteous gentleman of remarkable ability. He is one of the wonderful men who have brought out the best in municipal management with a long record of successful and businesslike water-works operations.

The principal in the Braintree Water Supply Company was Mr. William Wheeler, a member of this Association since 1889, and one of the most distinguished water supply engineers in the country.

I wish to especially thank the last two mentioned gentlemen for their assistance in furnishing me information, records, etc. in getting together this brief description of the purchase of these works.

# SHOULD THE WATER DEPARTMENT BE MERGED WITH OTHER MUNICIPAL DEPARTMENTS IN ITS MANAGEMENT AND FINANCES?

BY GEORGE A. KING.*

[*Read September 13, 1922.*]

Our late esteemed member, Frederick P. Stearns, said:

"I believe if any city had a system by which the public works could be wisely, prudently and honestly ordered, constructed and maintained, it would nearly have solved for itself the vexed problem of municipal government.

"It is self-evident that no system will insure complete success in the management of public works so long as it is possible to place incompetent and dishonest men in charge; but it is also true that the character of the men selected and the efficiency of their work depends very much upon the system employed, and the adoption of a good system is therefore a long step toward good government."

It is not to be expected that one man can be master of all the branches of engineering in the public works of a city, but by a division of the work it is possible to have a competent man at the head of each department and he will be able to give its problems the attention and study they need and this man should have executive control of his department to gain the highest efficiency and responsibility.

The size of the city may determine how this shall be attained, whether by a man at the head of all the executive departments with assistants in charge of each, or by separate heads for each department who shall co-operate where their common interests meet, regardless of the size of the city. The water supply which involves the health, happiness and protection of the community should receive the best and most disinterested consideration of the authorities. Consideration of economy is necessary but it loses its force and argument when opposed to the health and comfort of the people. There can be no financial measure of questions relating to the public health.

The management of a water department calls for a man of wide and varied experience. I cannot express it better than to quote from Hubbard and Kiersted on "Water Works Management and Maintenance":

"The maintenance and operation of a system of water works is often believed to be a purely business proposition requiring essentially a business management. Regarded in a broad and comprehensive sense this view may be correct, for a far-seeing business management would not over-

*Superintendent Taunton Water Works, Taunton, Mass.

look the purely technical or scientific considerations which are necessarily involved in the management of a modern water-works system. The questions involved do not relate solely to the sale of a commodity supplied in the form of a water service, but also deal with the quality of the water supplied and the design, construction and operation of the physical property by and through which the service is rendered.

"The selection of a water supply drawn from an unpolluted source is highly desirable and inspires the confidence of the public in the management of water works. This confidence, however, may be also secured when circumstances compel the use of a water drawn from polluted sources, provided the water be properly purified before use.

" Taking into consideration the many things which have to be regarded in the selection and purification of water supplies, it is clear that science can be serviceable to a water-works management in many ways, and the advantage of this kind of service should become more and more apparent as communities increase and prosper. If the aid of science is necessary to select a source of supply free from dangerous pollution or to detect the presence of unobserved polluting influences, its aid is even more necessary in those cases where a source of supply, known to be polluted, requires thorough purification. It will not suffice to seek scientific assistance in such a case solely for the purpose of designing and constructing purification works, but it should also be retained for the purpose of insuring the satisfactory operation of these works and the preservation of the purity of the water after treatment. The safeguards of the public health in the way of constructed works need guardsmen to see that such works positively perform the functions expected of them at all times — a service which may yet have to be supplied through the State or Federal government.

" To the requirements that extensions of, or additions to, a system of water works be made in accordance with good engineering practice, that the efficiency of a system from a mechanical standpoint and the sanitary quality of the supply be maintained or improved, should be added the requirement that the department be operated on a business basis."

Mr. Darling, in a paper before this association some years ago, said: " The superintendent should be a man whose *whole mind* is devoted to the work, but it does not follow that he must be able to affix C. E. to his signature, provided the services of one can be obtained at his convenience or his need." Ex-Mayor John O. Hall of Quincy later stated that no department contained more perplexing problems than the water department.

September, 1911, W. H. Richards of New London read a paper before this association in which he gave some of the qualifications necessary for a person in charge of a water supply and said that — " He should be an engineer in the larger sense, he should be ingenious, with a thorough knowledge of construction and tools, he must have, or immediately acquire, knowledge of the fundamental principles of hydraulics and above all understand the principles of business management — and with all these he has much to learn as the management of a water works requires special knowledge and he should have a logical mind to separate the theoretical from the practical."

I do not believe we are egotistic in making all these claims for our department and the qualifications we should possess. Can we expect to

find a man who will give to the water department what we believe it needs who also has on his mind the sewers, streets, parks, etc.? The public is more interested in its streets and parks and more insistent that these receive attention than in the water department which controls that which is much more essential to its health and happiness, and all thinking people must concede that it is the most important of all.

With the water department united with the others it will not receive the attention its importance demands. With the call for many other qualifications those specially needed in a water department will be overlooked. We all probably realize that the more closely we are in touch with problems and conditions the more important they seem to us and the more likely they are to receive the attention they deserve. Dr. Brown said a great many years ago that " the health of a city depends more on its water than all the rest of its eatables and drinkables put together."

The supplying of water to a municipality is not one of the original functions of town government. It is one of the necessities occasioned by our advance in civilization, the demand for which has been met by legislative enactment under the general provision that the legislature may grant what is necessary for the welfare and health of the community. It is a form of public trading, better known as a public utility, which the municipality has been allowed to finance principally for the preservation of public health and incidentally for fire protection and manufacturing purposes but not for the purpose of making a profit. As a public utility it should be managed independently of the general functions of municipal operations.

This argument for separate management applies also to the financing of the department. The paper of Mr. Hall, previously mentioned, states that " transfers of water receipts to various foreign departments of the public service are violations of law and of great injustice to water takers. Water expenses should be paid by takers and any excess of revenue over expenses should be returned to them in the form of reduce rates." Those who remember Mr. Hall will agree with me that he was a clear thinker and sound reasoner.

While it may not be quite pertinent to this question I will quote a little further from him. He says that the " expense of establishment of water should be borne by real and personal property of the community and should appear in the general tax." I do not agree with him wholly as I think that the interest on the debt incurred in construction should be paid by the consumer of water. Mr. Hazen and many others hold that the rates should also include a sum for depreciation which, of course, is good business and so recognized by public utility commissions.

In Massachusetts, the acts authorizing the establishment of municipal water supplies designate the methods of financing and there is a great lack of uniformity. Where the Director of Accounts, or his predecessor, has been called in for auditing and establishing a system of municipal

bookkeeping, he has recommended an appropriation for the use of the water department, the same as is done in the usual municipal departments and the receipts are turned into the general fund of the treasury, to be used as are the receipts from taxes.

In case of municipally owned lighting plants the statute (Sec.58, Chap. 164, General Laws) requires the rates to include "all operating expenses, interest on the outstanding debt, the requirements of the serial debt or the sinking fund established to meet such bonds, and also depreciation of the plant reckoned as provided in the preceding section, and losses." The depreciation referred to is 3 per cent. of the cost of the plant, "exclusive of land and any water power appurtenant thereto." The manager or municipal light board has sole power to draw on the treasurer for expenses of the department for the funds earned and additional amounts appropriated, if any. The Public Utility Commissions of Massachusetts, Wisconsin, and other states seem to be in accord on this method of accounting.

Why there should be this anomaly in the management of two municipally owned public utilities so closely related is difficult of explanation. While we may deprecate further state control, it is much better to be controlled by a commission who are experts in the management of utilities than by a board viewing the matter wholly from a bookkeeping point of view. Massachusetts General Laws, Chap. 44, Sec. 36 & 38, authorize the director of accounts to establish accounting systems on petition of town and city authorities and these accounting systems shall be such as will, in the judgment of the director, "be most effective in securing uniformity of classification in the accounts of such cities, towns and districts." You notice that the system is wholly for the purpose of securing "uniformity of classification." I think that the methods of accounting, required by the public utility commission, are more efficient and businesslike than those recommended by the Director of Accounts.

Ten years ago Morris Knowles advocated state control and quoted from Hon. John H. Roemer, Chairman of the Railroad Commission of Wisconsin, as follows: "No greater benefit has been bestowed upon the public by regulation of public utilities than that resulting from the operation of the law upon municipal public utilities. . . . . As a matter of fact, regulation is more necessary with a municipally owned plant than a private one; because people often endure service and rates imposed upon them by their own town officers which will call forth vehement protest if a private company were involved."

My belief is that the system under which the municipal light plants in Massachusetts are managed and financed is the best which has been devised for public utilities and that cities should adopt a similar plan for their water departments. It is not necessary to put them under state control to adopt this system and a general adoption of the system might forestall state control.

DISCUSSION.

PRESIDENT BARBOUR. This is a live subject, concerning which we have heard a great deal of talk by the various superintendents during the past few years. It ought to lead to discussion. It involves the question of subordinating the Water Department to a Board of Public Works, and of diverting the income of the Department to the general treasury of the city or town. It is a question whether under such conditions the morale of the Department can be maintained as well as under the old system, where a man was in direct charge of the Water Department and was credited with the results. I hope that there will be discussion.

MR. ALBERT L. SAWYER.* The Haverhill Water Department is one of those that has been entirely unmerged in all the course of its existence, and it has worked pretty well there. I think there are very few of the citizens of Haverhill who would willingly acquiesce to its being merged with the other departments of the city. The city took the works about thirty-one years ago, and the Act under which they took them provided that it should be kept entirely separate. It seems to me you get a continuity of policy in that way that you can't get if you are mixed up with politics and have the aldermen and councilmen deciding what the men shall do and what you should assign them.

In the first place, in Haverhill, what little money we have had has always gone into the development of the works, or into a reduction of the water rates. If we have a surplus it does not go into the municipal funds. Take the average city government, for instance. You have perhaps the Mayor or Chairman of the Board of Aldermen on the Water Board, ex-officio, and if they outline the policy at all, the longest they would probably be on the Board would be four years, and then you get a new set in and the policy changes. In Haverhill in the thirty years since 1891, we have only had seventeen Water Commissioners. One died in 1918 who had served twenty-seven years. We have another man on now who was appointed in 1894, who has served twenty-nine years; another who was appointed in 1899, who has served twenty-two years; and two other members have served eleven and ten years respectively. In that way they start out with a policy of what they want to do and they keep pretty well to it.

We used to say in Haverhill that we could generally trace out the residence of a councilman or alderman by the lamp posts in front of his house, and the edgestone on the street where he lived. I do not mean to say but that the Board of Water Commissioners are susceptible to those who howl the loudest for water, but they have tried to treat all applicants fairly. Haverhill extends over a great deal of territory, and now about everybody who has a farm out in the suburbs expects to have the mains extended.

The policy of the Water Board is like this: Those in need of water ser-

* Water Registrar, Haverhill, Mass.

vice who live along the highways seem equally deserving, and they usually endeavor to do a proportionate share of extension work along all lines each year until the work is completed. In other words, they try to treat all people alike who want an extension of the water mains and give each one fair consideration.

I have a letter here which I was showing to a water-works engineer to-day, and he thought it was possibly of interest to the members of this Association. It is a letter I received in 1908 from William H. Moody. Mr. Moody was, as probably most of you know, a lawyer in Haverhill, a member of Congress, Secretary of the Navy under Roosevelt, Attorney General, and then appointed to the Supreme Court of the United States. He was the counsel, in connection with ex-Governor Robinson, for the city at the time we took the works. In connection with a paper which I read before the Association in 1908, I wrote him and his letter in reply was as follows— I am going to read it to you because it seems pretty good common sense:

SUPREME COURT OF THE UNITED STATES,
WASHINGTON, D.C.
April 10, 1908.

ALBERT L. SAWYER, ESQ.
HAVERHILL, MASS.

*My dear Mr. Sawyer:* —

I hope you will excuse the delay in answering your letter of the 30th ult. I have been looking at the different acts relating to the Haverhill water supply and trying to recall the circumstances of their passage.

I might, with the aid of memoranda which I have at home, state the facts with greater accuracy than I can here. I am so anxious not to tell you anything of which I am not sure that I fear I can say little worth saying.

Of course I prepared the Act of 1891. So far as that act dealt with the scheme of management of the aqueduct property after it should be acquired by the City, it, I think, passed the Legislature as I prepared it. I do not think the Act is quite like any other but I must speak with caution on this point. This much I know; the main purpose which I desired to accomplish, carrying out in this respect the wishes of Mayor Burnham and the leading members of the very able City Council then in office, was to separate completely the Water Department from all other affairs of the City. It was hoped thus that the Department would be managed upon strictly business principles without regard to politics. To that end it was provided that the Water Commissioners should be appointed for a term of five years, that only one should be appointed each year, and that the City be left to pay for the water which it used like any other consumer. The power of management of the Department was vested exclusively in the Commissioners subject to removal by the City Council for cause.

I drew the Act of 1892 (Ch. 417) and put into it the provision that any land taken for the protection of the water supply might "be managed, improved and controlled by the Board of Water Commissioners in such manner as they should deem for the best interests of said City." The purpose of this provision was to enable the land thus taken to be used for the purposes of a public park as it since has been. I hoped for good results from this provision but I did not realize that the result would be a most beautiful park in which all our people may justly delight.

I drew the Act of 1896 according to my best memory. The purposes which it is intended to accomplish appear sufficiently from the Act.

I believe that this is all that I can say now which by any chance could be of service to you.

Very sincerely yours,

(Signed) W. H. MOODY.

Now, we started out along these lines, and, as I say, it has worked very successfully. The Water Department has been entirely removed from politics. The only connection, in fact, that we have with the Municipal Council, is the appointment of the Water Commissioner each year and the auditing of our accounts by the City Auditor. Outside of that, of course if the Council makes recommendations of certain things, the Board would carefully consider them. But we have never been interfered with, and I do not think many of the citizens of Haverhill would advocate merging with other departments of the City.*

I might say, as a shining example of keeping out of politics, that last May I completed thirty years' service in the Water Department of Haverhill, and I presume if it had been in politics I would have been fired years ago.

MR. A. R. HATHAWAY † (*by letter*). Pardon me for following you to New Bedford by letter (for that is the only way I can follow you), but I was just looking over the program and note you are down for the question "Should the Water Department be Merged with other Municipal Departments in its Management and Finances?" and I wish I might be there to hear your paper and to add my little say against any such merging.

But you know that in such matters the man that has had over forty years' experience and observation is not as well qualified to pass on such questions as is the young "expert" (so-called) from the modern Bureaus of Research, and the charter agitators of the present day.

However, if there should be opportunity to be recorded on the proposition I wish you would put me down with an emphatic "No."

You and I know that every water works, *municipally owned and operated*, is all the time bucking between two influences; that of the honest and conscientious water official for an up-to-date *business adminstration* of its affairs, and the beneath-the-surface (often above the surface) influence of the politicians and their followers for a *political administration;* with the chances that the latter will sooner or later control, when the water works will lose its natural standing of a public utility.

I think every *thinking* citizen will admit that a water works, like gas and electric works, street railways, telephone systems, naturally belong to the *public utility class*, and in former years were more largely owned and operated by private corporations instead of municipal; that such private corporations, in order to obtain the best results, adopted all modern practices and devices and are controlled in every state by some form of of Public Utility Commission, which protects both the corporation and

* Our water act provides that the Water Commissioners shall fix the price or rent for water supplied annually; and the income received therefrom after deducting all expenses and charges of distribution shall be applied, — first to pay the interest on bonds issued; second to pay the sinking fund requirements for loans; third to the payment of all current expenses; fourth the balance if any, may be applied to the sinking funds at the discretion of the Commissioners. The Commissioners may expend from the annual receipts for the purpose of new construction, a sum not exceeding twenty thousand dollars in any one year. Our officers are not in City Hall but in a separate building leased by the Water Board, and we handle all receipts and expenditures.

† Water Registrar, Springfield, Mass.

the people served, and that they thus can be operated for good service and also to the payment of dividends to their owners, the stockholders. And I maintain that a change to municipal ownership does not, or should not, alter the fundamental status of such water works or its relation to the public served; that the fundamental practices of best operation under a private ownership should certainly be followed under a municipal ownership, in order that the fullest measure of public service and the best financial results may be obtained. The only way to insure these results, to my mind, is to treat such municipal water works (not as one of the governmental departments of the municipality, which are supported by tax levy, but) as an independent investment of the city, to be self-supporting and operated on purely business and public utility lines. The more it can be divorced from other departments and political control, the better operating results you will reach in the long run.

Without legal authority perhaps, we are trying to educate our citizens away from the " department " idea by placing on our stationary and bills, etc, the words " Muncipal Water Works " instead, as shown at top of our letter sheet.

MR. PATRICK GEAR.* Considering criticism of the man that is doing more for the Water Departments of New England and Massachusetts than any man that I know of, or ever heard of, and hear the criticisms that he has to stand from those who don't know the business that he is attending to for the people of the State, look around and see what other Departments do to defend the people and promote their interests. When the Commissioner of The Massachusetts State Board of Education advocates anything every superintendent in this State is back of him to help him out; when the State Department of Public Health tells us how the water is to be taken care of in the State, we put our hands in our pockets and let the director fight it alone; and when different cities and towns take it into their heads that they will bring the water and the fire and the streets all under one man, I get a little hot. If you make that man the king-pin of the city, the Water Department will be bled to help out the Highway Department, and in a few years you will find that the Water Department has not got anything to put out a fire. I know of some cities where they change the Water Commissioners every time they change the Mayor, and they change the Mayor every time they have a chance to elect a new one. In a dry summer or a cold winter, they have to buy water from their neighbors. I believe that there is only one right way, and that is to let the Water Department have their funds and not come to them every time they have a little money in hand that they do not want to use right away. Let them put it into their plant, and if they have not a chance to put it underground they can put it on top of the ground where it can be seen, so that everybody will realize they are doing fine work. All our good work is buried. It is difficult sometimes to make people believe that we are doing good work, until a fire occurs.

*Superintendent Water Works, Holyoke, Mass.

I think the Water Departments of the State should stand back of the State Department of Health in everything they do, and if they find a city that wants to merge the Water Department with the other Departments, go to the State House and fight it out and say, "We shall not let you do it." But if you let them bleed the Water Department, tax you for it, put it into the streets, build up a Fire Department, build up a fine park system at the expense of the Water Department, it will be poor economy in the end. There is a fine city in our part of the State that takes $30 000 or $40 000 a year out of the Water Department and puts it into the other departments. That is not right. But do not reduce the rates too low. They are not high in this section of the country. In Holyoke the money is kept in the department.

MR. CHARLES W. SHERMAN.* I am inclined to think that there is, perhaps, greater danger to the smaller cities and town than to the larger ones. The development of a plan combining all the public works of a municipality is not so dangerous to the larger community in which each department is of such magnitude that a man of considerable ability is necessarily employed in charge of it.

In the smaller cities and towns, on the other hand, everything may be put in the hands of a man who can't be a specialist in all lines, with the result that the man in charge of another department than the one in which he is particularly interested is practically only a foreman under him, with no great authority and with no prestige behind him, and the department of which he is in charge suffers in consequence.

I was considerably impressed by Mr. King's argument in favor of proper accounting for the Water Departments, and recommending for our consideration the form of accounting recommended by the Utility Commission for Electric Light Plants. Perhaps many of our members are not familiar with the fact that in Maine all Water Departments, whether publicly or privately owned, come under the Utility Commission. The Public Water Departments have to make exactly the same returns to the State Utility Commission that the private water companies do, in Maine, and I believe it has been a mighty good thing for them. The smaller water departments in too many cases, especially country places, have no accounting system worthy of the name, and the Maine Utility Commission, which has now been doing business along this line for about eight years, has done wonders in putting those things on a more scientific basis. Of course the older companies which did not have much of any records to start with — I hate to use the term, but I must say that they had to "fake" some to start with, and perhaps what they used as basic figures are not above suspicion. But the figures which are being added annually do really mean something. I think other states might well follow Maine to that extent, by putting the accounting of the Water Works of a publicly owned utility on exactly the same basis as a privately owned one.

*Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

MR. HENRY A. SYMONDS.* About 1914 a bill was entered in the Massachusetts Legislature to put the water companies of Massachusetts, which had been up to that time under no special regulation, under the, Gas and Electric Light Board. It seemed at that time to the water companies that this was going to entail a great deal of extra work, that it was something which the companies would not get much real benefit from, and that there was going to be a large expense involved. The result was that when the bill was entered, the first year, I think there was almost unanimous opposition from the water companies. The bill was again entered the next year, not much opposition developed, and it passed and became operative in 1915. I think the first year the companies did the work rather grudgingly. Of course a great deal of work was involved in getting things straightened out along the lines required, and there was considerable complaint from the water companies all over the state. The second year, as things had been somewhat organized and the information collected, the companies did not find as much fault, and I think about the third year they commenced to rather like the idea. It became easier, and we found we were getting a great deal of benefit out of those reports, and out of keeping the systematic accounting and complete records of the physical plant. That has come to-day, I think, to be recognized as having been an excellent move not only for the general public but for the public utility companies themselves, and really a much greater benefit for the public utilities than for the general public.

Mr. Sherman has just mentioned that the State of Maine Water Departments have been placed under public control. I think Connecticut is also under a similar regulation. In Connecticut, and I presume the same is true in Maine, and perhaps in other places, the report of the physical plant is being required along the same lines as is required of the private water companies. That is something which, to those who are looking for general information, general data relative to development work and the operation of the plants, is of very great value. The simple, uniform accounting is a step in advance but, added to that, the uniform statement of the operation of the plant, from not only the companies but from all municipal plants, would be of very great benefit when made accessible to all operators. It would be one of the best things which Massachusetts, and the other states which have not taken it up, could do, — to place these plants, whether publicly or privately owned, under Public control and establish a standard basis not only of accounting but of all operating records.

MR. KING. Some weeks ago I wrote to Mr. Whitney of Newton asking some questions about their system, and last Monday I received this reply:

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* Consulting Engineer, Boston, Mass.

CITY OF NEWTON, MASSACHUSETTS.
CITY HALL,
WEST NEWTON.

MR. GEO. A. KING, September 9, 1922.
Supt. Water Works,
TAUNTON, MASS.

*My dear Sir, —*

The Charter of the City of Newton provides "The Water Department to be under the charge of the Water Commissioner who shall have charge of the construction, alteration, repair, maintenance, care and management of the Water Works."

There is no "Board of Public Works" expressed or implied in our Charter or Ordinances, though the Mayor as the Executive head of the City can, if he so chooses, assume such management.

However, to a very fair degree coöperation between Newton departments exists with but few cases of overlapping or interference with each other. Men capable of managing more than one department are few in number and corporations secure most of these.

Consolidation of an income-producing Water Works with other departments "lean and hungry," results at times in the absorption of any surplus income by others and obliges the Water Works to almost go on their knees for sufficient funds to keep their plant in reasonably good condition. It is sound finance to use Water Income for Water Department purposes only, and I believe the average citizen gets more satisfaction in dealing with a Water Works than with a small division of a Public Works Department.

Very truly,

(Signed) J. C. WHITNEY,
*Water Commissioner.*

MR. M. N. BAKER.* A phase of this subject that does not seem to have been touched upon is that one of the great difficulties in the smaller places is to get a really trained and experienced man to handle the separate departments. It is often quite beyond the financial possibilities, or is thought to be so. If, to use a familiar expression, we say that the City Manager form of government is adopted for these smaller places, you at least have a man who is trained in municipal administration to run all of the departments.

It is because municipal government of late has been taken up from the viewpoint of the city as a whole instead of being split up into many and largely independent departments, that there has been this tendency to consolidation.

New England is accustomed to Water Boards, and looks upon them with favor because they have been largely continuing bodies. But looking at the subject from a country-wide viewpoint, we find quite different conditions prevailing elsewhere.

We have to-day in the whole country doubtless 500 to 600 cities that have the Commission form of city government, whether with or without City Managers. It is the change to the Commission plan of government which has brought about in a large number of cases changes that have affected the several departments. We need better city government and

*Associate Editor *Engineering News-Record.*

we must look at the city as a whole instead of at each separate department, and where there is a Water Board and a Sewer Board and a Light Board, as they still have in some places, and used to have in many, independent of each other and of the City Council, haphazard system of government is the rule, and it is impossible to have that unified control and central responsibility that is essential for efficiency and economy of municipal administration.

The basic thing is to see that in the management of the water and all other departments, scientific principles of control are established and enforced to make sure that the Water Department, as has been suggested, stands on its own bottom, with water rates fixed to provide properly for operation and maintenance and take care of capital, and to ensure that the Water Department revenues are not robbed, as they have been in many cities, to pay the expenses of other departments.

Finally, the single-headed Commissioner is now generally considered by careful students of municipal and state government to be far preferable to the Board of Commissioners for the exercise of excutive functions.

MR. GEAR. Regarding this commission form of government. Of course the agitation was started by a class of people who think they can reform human nature. They will have an awful job.

Our Water Department has always been kept separate from any other municipal department. There is no reason in the world why one man should govern two departments. If one department is getting an income, the other departments are trying to spend it. One Board should never cover the two. The old system of government that we have had for hundreds of years is fairly successful, and the new forms just a fad.

I have not seen any improvement under city managers. Some of the cities that had them have gone back to the old system.

MR. DAVID A. HEFFERNAN.* Up to 1902 we were a private water company, having a Board of Directors of course, and a President who took a very great interest in the equipment of the plant. Plans were formulated to use certain types of gates and hydrants, and run on the principle of uniformity. After all the time that I have been in the employ of the Town of Milton, thirty-two years, I was wondering, if I retired tomorrow, what would happen to the present equipment. Uniformity of gates, hydrants and other equipment standard in all ways, opening to the right, and giving perfect satisfaction. The result in changing over to a town manager, or to a Commissioner of Public Works would be that probably the whole system would be revised by a man coming in with different ideas, thinking that the equipment of the plant is passé. I will admit that there are other equipments as good as mine, but when you get a thirty-two-year-old system, with thirty-two years of service, and still going and giving satisfaction, I think it is creditable.

* Superintendent Water Works, Milton, Mass.

To-day we have committees on Standardization. For what purpose? Just for the very purpose we are talking of to-day, because of the changes in government through politics and the like. Different Commissions being elected, different materials, different types being introduced into that system, result in not knowing what you have there; you have special threads — you don't know what they are. I am on a Committee on Standardization of Brass Fittings. We have been on that for three years, not having made much headway, and I am afraid we will not make much, for the reason that there are certain fixtures on the market which control practically 75 per cent. of the Water Departments. They have special threads. The manufacturers even go so far as to say that the standard thread is passé. I can show you an advertisement in *Fire and Water* stating that the standard thread to-day is passé. Just think of it!

MR. R. J. THOMAS.* The motive behind Mr. King's paper probably may not be understood by a number of the water-works people here. That is to say, they do not realize the tendency that is prevailing in Massachusetts to-day, and in probably some of the other New England States, to abolish the Water Department as a separate department, and place it under a Board of Public Works, simply making it a subordinate branch of the City Government, without a Superintendent. That tendency is growing, and probably several cities now with water works organization, will be merged under a Board of Public Works within the next year or two. It is an evil tendency that is going to make for poor management of water works and we, especially the Massachusetts members of the New England Association, ought to organize to do what we can in opposition to it.

In regard to this discussion that has been brought up, by Messrs. Sherman and Symonds, of the State having some control and regulation of the publicly as well as the privately owned plants: That may be a remedy. But something has to be done to prevent the Water Works Departments from disappearing in many of our municipalities in Massachusetts. There are quite a few cities in New England that are not represented here to-day, because nobody connected with them is interested in water-works matters to the extent of coming to these meetings. About a year ago, I had a conversation with a man who was head of the public works department in one of our New England cities. I asked him why he did not attend the water-works meetings. He did not think it profited him to come. In that same city at one time lived a president of the New England Water Works Association, who was a very able president, and superintendent of water works, and he has left his impress on that city to-day. The water works as he designed and built it is furnishing not only that city but several neighboring towns with water. But his successor who also has other branches of the public work to take care of, thought it would not profit him to come to these meetings. I suggested to him that it might profit the Association if he came.

* Past President American and New England Water Works Associations.

It seems to me that this is a live question, especially because they are taking the revenues of the Water Department and using them for other purposes. I remember some years back, the Water department of the City of Fall River had $80 000 surplus. They wanted to put in a new standpipe, but the City Government appropriated the $80 000 for other municipal purposes. The mayor was friendly to the Water Department and he held it up until the Water Commissioners had time to act. Representatives of the Water Works Association went to the Legislature and had an Act passed. We supposed at the time it was going to be a general Act to prevent the taking of water-works revenues for any other than water-works purposes, and that it was going to apply to all cities, but as passed it simply applied to Fall River. It should have applied generally.

I know of a case where a member of the Legislature introduced a bill to reduce the rates in his city, for the sole purpose of making himself popular, that he might be elected Mayor. But he proved one of the worst Mayors they ever had. Reducing the water rates is popular in a great many places. The Board of Public Works could take care of that feature so that the rate will not be reduced unduly so as to promote the interests of any man who is seeking to be Mayor or any other public officer.

I think we ought to get this matter studied and see that there is a defense organized against these attacks on Water Works Managements in our cities and towns in Massachusetts or Rhode Island, or wherever it is necessary.

MR. J. W. DIVEN.* The using of water-works funds, or any part of them, or the surplus, for general tax purposes, is certainly an inequitable form of taxation. It is not a tax based on the value of the property, because it is a tax on the users of a commodity. A manufacturer using a large amount of water is paying a tax way beyond the proper tax on the valuation of his property. Certainly a water-works fund, if they do create a surplus, should be used by the water department, possibly for retiring bonds or for depreciation. If they have not use for a surplus then they should not create a surplus. In other words, a municipal plant should base its rates on the actual needs. If the revenue is larger than is needed for the operation and proper maintenance of the plant, then reduce the rates. Certainly to use that money for other city purposes is taxing the commodity user instead of the value of the property.

MR. GEAR. We have done that a few times. We created a surplus of $40 000 and used it to extend a main five or six miles into a new territory. It could not be done with the surplus from one year.

A 24-in. pipe line 4 mi. long is proposed for next year. We are creating a surplus now, and have been for the last couple of years, to carry that out. We do not intend to borrow any money to do it. Some people think when you have a surplus one year it ought to be taken away from you.

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*Secretary American Water Works Association.

MR. DIVEN. You are creating a surplus for needs. I said, not to create a surplus in addition to needs. It is a question whether it is right and proper to use the surplus of the Department for construction work. By using your surplus you are taxing the large user of water, the large manufacturer, perhaps, to extend the mains. To my mind extensions should be made out of capital.

MR. KING. When I first began to study this subject which you assigned to me, I came up against the part which Mr. Baker referred to, — the difficulty of applying a system to a small municipality and to large cities like Boston, Worcester, New Bedford and Fall River. I could not see how I could say anything that would fit all those places, and so I had to write in a very general way. I think one great difficulty we meet with is the lack of appreciation of the benefits which people receive from the water system. Just an illustration: during the war time when we wanted coal, what rating were we given? About third class. We could have it after two or three other classes got it. I went to the Manager of our Coal Company and told him what they would lose if we could not pump water. He said," I will see that you have coal; I did not realize your importance." I think that is the feeling all through, the people do not realize the importance of the Water Department, and when you consolidate with other Departments the other Departments are going to have the attention, almost exclusively, of the party who is put in charge, unless he happens to be a water-works man.

Mr. Sawyer touched on the continuity of purpose of the Water Boards. We have had in our 46 years, including the members we have now, eight Commissioners, — three at a time. I think that has given a continuity of purpose all these years, and that the City of Taunton has benefited by such service.

The President wants to know the good of all this talk unless we do something, and I would move that a committee be appointed from the Massachusetts members to consider the advisability of taking some action with the State authorities on this matter.

MR. DIVEN. Why confine it to Massachusetts; why not the other states?

MR. KING. Years ago we had a matter come up in the Legislature and this Association voted to assist. A circular was put out and Mr. Kent signed it as one of the members. He was from Narragansett Pier. That was used against us, — that a man from Rhode Island should be trying to influence the Massachusetts Legislature. We have to watch all those things.

MR. MICHAEL F. COLLINS.* There is one point I want to bring up and I think it might be added to Mr. King's motion. A number of years ago this Association formed a committee to appear before the Massachusetts Legislature and have a measure passed that would make water taxes a lien on the property. Last year Mr. Sullivan of the Boston Finance Commission introduced a motion, and I believe it was passed by the Committee on

* Superintendent Water Works, Lawrence, Mass.

Cities and Towns, that the City of Boston should be authorized to have all their water assessments placed as a lien on the property. I have spoken to a number of men I know, and to a few members of the Legislature, to have them do what they could in order to have that measure passed. I told them at that time that the City of Lawrence was badly in arrears on water bills. In our city we have had a number of property brokers that have been passing the same piece of property over, sometimes two or three times a month, so that it is almost impossible for the Water Department to keep track of them, know who they are and from whom the money is coming That measure was introduced but was defeated by some of the property owners of the City of Boston, though the committee reported favorably. I believe at that time there were a million and some five or six hundred thousand dollars due the city of Boston for water assessments, and everybody thought under those conditions it would pass, but it did not.

Now, if such a bill could be embodied in the motion made by Mr. King, that this same committee take under consideration the advisability of bringing the bill before the next Legislature, I think with the coöperation of the City of Boston, and with the help and coöperation of all the Massachusetts Superintendents and their friends, that there would be no question of doubt but what that measure would go through. If it did go through so that money so owed on property would at the end of a year, if it was not paid, go on a tax bill, I think all the Water Departments of New England, and of Massachusetts especially, would be benefited by it.

MR. DIVEN. My point was that other states might need it as much as Massachusetts.

SECRETARY FRANK J. GIFFORD. Would it be wise, in view of the fact that you are trying to divorce the Water Department from other departments, to get a bill through which will relieve you by having the Tax Department collect your bills for you?

MR. COLLINS. I do not think that would have any bearing on the subject at all.

MR. GIFFORD. There might be a question whether you were looking for help from other departments, when you want to run your own department. You have the power of shut-off at any time.

MR. COLLINS. But you have that after the property is sold, and you can't make the purchaser pay the back bills.

MR. GEORGE F. MERRILL.* That is a good suggestion. I think they should be entirely separated if we go to any State authorities for action.

PRESIDENT BARBOUR. I will now read Mr. King's motion as he has written it out: "It is moved that a Committee of Massachusetts members be appointed to consider the advisability of united action with State authorities of Massachusetts on the subject of merging the Water Departments with other Departments in management and finance, or either of them." (This motion was duly seconded and carried.)

* Superintendent Water Works, Greenfield, Mass.

# WHY WE SHOULD INSPECT WATER-WORKS EQUIPMENT.

BY THOMAS E. LALLY.*

[*Read September 13, 1922.*]

The remarks I shall make in this paper I hope will be of interest to superintendents — and this paper is offered with that idea in view.

Superintendents are usually criticised when some part of the system fails. These failures are usually accompanied by a flood resulting in damage to basement property or damage caused by wash across property to lower elevations, and in most cases the newspapers have pictures of the flooded area and the heaved street, and the article usually ends with some such statement as " After considerable delay the water department shut off the water and the geyser subsided," or " The water department, after frantic efforts to locate the gates, finally shut off the flood."

When the broken pipe is examined, the iron is usually found in good condition, no thin places in the pipe, but something caused the break and the department is criticised.

Again, we find a thin place, a bubble covered by a thin layer of iron on the inside and the outside of the pipe, or a joint, like that in a roll where the iron never ran together and the water was held in the pipe by the tar filling the seam when the pipe was dipped, and it remained for a shock or a jar to start the water through and then the pipe let go and you had a flood.

I am not going to speak of blown joints, as they belong to another class.

In your fittings you will find these same faults and others. The knob on the side of a curve or over the place where the branch leaves the straight pipe leaks copiously. This is caused by a loose chaplet that was placed there to hold the core in place in the mold, and when the iron was poured it did not cement itself to the chaplet. You are laying some new lines and find your lead space a bit small, or have difficulty in entering a spigot into a bell, and perhaps have to chip off the bead. Then when the water is turned on and the pipe gets the pressure you see a large area that " sweats" showing porous or spongy iron in the walls of the pipe or fitting; all defects that may cause a bad leak some day.

You try to shut down a line, and after going through the motions of closing a gate, get a flood of water in the trench and have to go back and close other gates to stop it. Leaky gates may have the seat stripped off because something caught under the valve and the seat was not pinned

* Assistant Engineer, Public Works Dept., Boston, Mass.

in. A gate was operated by the crew and they could go on turning forever. The nut in the top of the valve was not pinned in when the gate was built and the stem has turned it out. You remove a gate box cover in the street and find the gate gland leaking badly. Either there was too little packing in the gate or it was not put in properly. I could go on indefinitely with these incidents, but they all go back to inspection.

In the course of my observations in the inspection of water-works equipment, I found the run of men making these things, that is, the owners, want to do a good job, sell their stock and make some money. It is usually some of the people in the lower list of employees who think it is smart to push along a piece that is not what it should be. This is where the inspection comes in. If your equipment is inspected (and by inspected I do not mean just looked over), many of these defects will be found; and if they can be corrected at the time and do no harm to the piece, the inspector will have it done, if not he will reject the piece and you do not get it in the system. I want to say right here that it is my belief that every inspector gets fooled or as the saying is " has it put over on him " sometime or other, whether he finds it out or not. The presence of an inspector where material is being fabricated will have a deterrent effect on any tendency to slight the work.

The inspection for the City of Boston is rigid, and I think all equipment should be rigidly inspected either at the place of manufacture or at the local yards or shops. In the inspection of main pipe the inspector finds a pipe with a scab on it and rejects it. Why? Well, the pipe was cast in a tight flask, and it is certain to begin with that nothing got out, therefore the piece of core or mold is in the walls of the pipe. Probably it has broken up into many small pieces and is scattered all through the pipe. Perhaps it will be found in a lump stuck in the narrow wall with only a thin layer of iron around it, a shell with a dirt core. At any rate the dirt is in the pipe and you do not want the pipe.

Some foundries now pour their pipe with a large riser or head the full diameter of the pipe. In fact it is really an extension of the pipe beyond the bead, this to catch all the dirt that may be floating on the iron when it comes up. Then they cut off this riser, leaving a good bead and clean spigot. But are you sure all the dirt got to the riser?

The writer knows of an instance where a piece of dirt broke off of the mold in a pipe 1.25 in. thick and caught in the narrow wall of the pipe and was imbedded in the iron. The pipe was passed to the hydraulic test and stood the required 300 lbs. without leaking; was subjected to the hammer test, and because the inspector's hammer happened to hit on that particular place and broke through, allowing the water to spurt out, exposing the weakness, the defect was found. Otherwise the dirt would not have been discovered, the pipe passed, and after being in the ground might have started a leak, the magnitude of which it is only possible to guess. There was only $\frac{1}{8}$-inch of iron in the wall on either side. Again, —

inspection. Had this pipe been laid on poor soil where corrosion is rapid and pitting takes place, or been subject to water hammer, a leak would have developed, washing out the support, causing settlement, a broken line, a flood, damage and more criticism to the water department.

Roughness is another cause of rejection. I am inclined to think that the ordinary foundry roughness is smooth in comparison to the roughness that pipes acquire after a few years in the ground, due to tubercles forming on the inside of the pipe and retarding the flow of water many more times than the ordinary foundry roughness.

The inspection of main pipe has been so ably covered by other writers before this Association that I will not take your time to go into it more at length. However, I want to impress on you, in these days when it seems that every person not a producer is considered a load to the economic system, that an inspector, while not a producer, is a protector.

In the manufacture of gates or valves for the City of Boston Water Service we require the gates to be finished in a workman-like manner, to be inspected and tested. During the past fifteen years this service has had many hundred gates built outside of its own shop. The city furnishes everything necessary to assemble the gates, in the rough — iron castings, composition castings and flange bolts, gasket and packing. The contractor does all machine work, assembles the machined parts, tests and delivers the finished gates to our yard. The machine work is inspected before assembling and must conform to our standards both for finish and size and type of threads, and all similar parts must be interchangeable. The iron is tested through test bars 26 in. x 2 in. x 1 in., which are broken on supports 24 in. apart with a center load. They must show a deflection of at least $^{3}/_{10}$ in. under a load of 1 900 pounds before breaking. The castings are inspected at the foundry for size, thickness of walls, dirty or spongy iron, cold shuts or blow holes. The general character of the castings is noted, also their roughness. This latter does not affect the worthiness of the castings but it does affect the disposition of the machinists that work on them.

The composition is furnished in the rough as I have said before. This was made at a foundry having a contract to furnish our material, and test bars had been taken and pulled for tensile strength, after which the turnings were analyzed chemically. This has been done before the castings were accepted by the city.

Of course defects show up in the machining. If these unfit the piece for the purpose for which it was intended it is rejected. With iron parts, hard iron, blow holes and dirt show when the skin is turned off. Sometimes spongy and porous places are exposed, causing rejection. These defects are of such a nature that it is unreasonable to expect the foundry inspector to find them all. However, if there was no inspection some of them at least would find their way into the finished product and in a few years would give trouble. In testing the gates the City of Boston requires that

the gate be closed on one bell by a cap or head; the closed bell and gate is then filled with water, the valve is slightly raised, allowing the water to fill the bonnet, the air escaping through the gland which was loosened for that purpose. After the gate is full of water the valve is closed down tight and subjected to a pressure of 150 lb. per square inch, when any leakage through the valve either under the seats or between them is readily seen on the open side. The process is now reversed and the other side tested. This process duplicates the conditions in the line as near as may be and has been found very satisfactory. It shows up defects and exposes spongy places in the castings. It is preferred to the method of tapping in a piece of pipe in the bonnet and subjecting the bonnet and the parts surrounding the valve to the pressure but getting no pressure on the bells. This latter method is cheaper for the manufacturer and consequently is in almost universal use in commercial gates. It is my opinion that the commercial method is of advantage in the type of gate having loose discs because it tends to force both discs into seat at the same time at one operation. With the solid wedge type of gate which we use I do not advocate it; and as I said before, it gets no pressure on the bells. Our method will detect the slightest difference in taper between the seat in the body and the valve rings. As our gates are under pressure of from 25 to 100 lb. in the line and a very large percentage never get a pressure of over 50 lb., I believe 150 lb. test pressure is adequate. I do not believe in putting on an excessive test load and straining the castings uselessly, 50 per cent. overload being enough.

We also require the beaten in seats and valve rings to be pinned. This may seem a needless requirement as most commercial gate salesmen will tell you that their particular type of dovetail never pulls out. Certainly ours does not, and that is what we are after. The nut through which the stems in all gates over ten inches operate to lift the valve is also pinned in to prevent the stem from turning it out. This is also a matter of precaution and does not add but a trifle to the cost of the gate.

Sometimes we find gates, before acceptance, where the nut used to keep the stem from rising in the bonnet is omitted, depending on the gland to hold it down; others where the packing is poor; some leak between the flanges, showing defective gasket or loose flange bolts, leaks under the seats, between the seats, and it is not beyond reason to think that some of them would get into the line if it were not for inspection.

These instances are given to fix in your minds some of the defects that may be expected when materials *are* inspected and also you may infer what you get when they are *not* inspected.

In our hydrants, it is important in the compression type, of which the City of Boston has several sub-types, to see that the caps on the outlets are tight when the barrel is under pressure, that the gaskets between the stuffing box and the head of the barrel and between the bottom of the

barrel and the pot are good. In our newer type care must be exercised that the waste closes before the main valve has any more than just started.

Many of the water departments use iron or steel pipe. Do you get the material your order calls for? Do you inspect the lengths for splits and burrs before you line it with cement? Perhaps in a whole car load you would get not more than half a dozen defectives, but if these get into service and develop leaks it will cost you many times the cost of the tests to replace them, and the public is not inconvenienced by tests of this kind.

With brass fittings which are smaller, you are able to take them in your hand and naturally you or your foreman look them over and it is easy to see their general condition. But are the cocks tight, do they turn easily? What about the make up of the metal? This you would only know from inspection.

In this age of fierce competition, when each concern is striving for your orders, making hundreds, yes, thousands of the same kind of pieces, labor uncertain and overhead charges heavy, a fraction of a cent saved on each piece means profit. It is an easy matter to take a turning off of the inside of a pattern cutting down the weight while the outward appearance is not changed, put one less bolt in a flange or an ounce or two less metal in a stem, and the buyer does not notice it. I was told by the superintendent of the practice of one large concern in weighing ten of their pieces against ten similar pieces of their competitor and making theirs meet the competitor's. It means cutting down the factor of safety by which you guard the public. Some manufacturers resent the presence of an inspector in their works. They seem to think that their business honesty is being questioned. Well, to be frank with you, if the City of Boston, during the past few years, had not had some good inspectors in the Water Service to look out for its interests, the taxpayers would have received some pretty poor returns for their money.

I am of the opinion that a good article is worth a fair price, will last longer, will give the best service, and will cost less to maintain; that a cheap article is in every way temporary in its usefulness, will give poor service and cost more to maintain.

Why do we inspect our water works equipment? To see that we got what we contract for in number, weight, and quality.

## Discussion.

Mr. Percy R. Sanders.* What is done in regard to testing the pipe fittings, 6 in. x 6 in., or 8 in. x 6 in.? I understand those are not tested under water pressure where they are made.

Mr. Lally. In the City of Boston we furnish our patterns and the contract is let to make the castings and the fittings from these patterns, and we have an inspector at the foundry where they are being made, and he inspects them with a hammer without any hydraulic test. He measures them, calipers the thickness of the walls, and does all the testing except hydraulic. They are not tested that way. The fittings for the high pressure fire system in the City of Boston were tested under 600 lb. hydraulic pressure in much the same manner that the main pipe were tested, and subjected to the hammer while under pressure. I will say that they got a lot of them that were porous. The pipes ran very thick, and it is hard to get thick pipe without getting porous iron.

Mr. David A. Heffernan.† What is the percentage of copper in the alloys of the brass fittings?

Mr. Lally. We have three grades. The No. 1 is used for stems and bolts, and calls for 88 parts of copper, 10 of tin and 2 of zinc.

Our No. 2 metal is used for everything else except stems and seats that have to be beaten in. It is composed of 84.2 copper, 7.4 tin, 6.3 zinc, 2.1 lead. It is a soft metal and makes a good valve for the inside of the gate, but where it ever came from I do not know. It has been in the water specifications for twenty years to my knowledge.

The No. 3 metal that we use is nothing but ordinary brass, — 3 of copper and 1 of zinc. That is only used for valve seats that are beaten in.

Mr. Heffernan. I think the City of Boston uses plug curb cocks — as high as 1½ in. If that is true, is there any difficulty in regard to operating those plug cocks?

Mr. Lally. Inch and a half, I think, is the largest size that we use, but we formerly used a 2-inch. We put in an inch and a half cock, with increasers, usually, where a 2 in. pipe is used immediately behind the cock. I will say that they do open very hard after awhile. Operators drop heavy wrenches down, which has a tendency to drive the plug in, and sometimes they have to be dug out.

Mr. Heffernan. Some communities are using plug cocks, as high as 2 in. I can't see how they can get service for any length of time from a large cock installed under ground, or how they can depend upon its working.

Mr. Lally. I will say now that they are using a 2-in. valve with an extension on it on 2-in. cast-iron pipe for services instead of lead. It is the regular standard commercial valve with an extension stem coming up

* Superintendent Water Works Concord, N. H.
† Superintendent Water Works, Milton, Mass.

to the street, and a small nut put on that would not be operated by a regular gate wrench. Our regular gate wrenches take in everything from 4 in. up to 12. The 16-in. has a different size nut on the top of it. Formerly they used some of these 2-in. gate valves, and there was nothing to operate after the wrench was dropped down into the hole. So that they have brought these up in an extension to a 1-in. square nut just under the cover.

MR. E. M. NICHOLS.* How long have these specifications been in use?

MR. LALLY. I think since '98. But for the benefit of the gentleman, who evidently takes a wrong impression from the date, the metal can't be beat to-day.

MR. NICHOLS. I am inclined to disagree decidedly with the gentleman that the the metal can't be beat. It can be decidedly improved upon.

MR. RICHARD J. FLINN.† What is considered the best packing for the stuffing-box?

MR. LALLY. I won't say that we consider it the best, I do not — but what we use is ordinary wicking that has been boiled in edible tallow.

MR. FLINN. We use granulated cork for packing, and have for ten years.

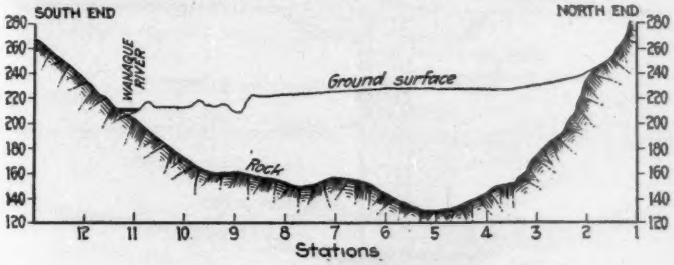
* Civil Engineer, Philadelphia, Pa.
† Mechanical Engineer, Boston, Mass.

# THE DEEP CORE-WALL OF THE WANAQUE DAM.

BY MAJOR ARTHUR H. PRATT.*

[*Read September 13, 1922.*]

The Wanaque Dam, under construction by the North Jersey District Water Supply Commission, will impound the waters of the Wanaque River, one of the tributaries of the Passaic River, at a point about 25 mi. north of the city of Newark. The Wanaque Reservoir, which will supplement the present Pequannock River supply for Newark and will also serve other neighboring municipalities, will impound between 11 000 and 27 000 million gal., giving a safe yield of 50 to 100 m.g.d., depending upon the needs of the municipalities which decide to enter the project. The reservoir will be about 6 mi. long and 1 mi. wide.



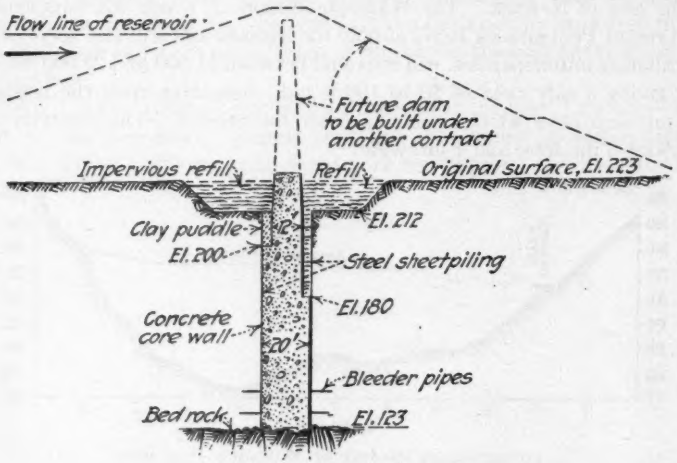

LONGITUDINAL PROFILE OF WANAQUE DAM SITE.

The site of the dam is across a valley about 1 500 ft. wide which is to be closed by means of an earth dam having a concrete core-wall extending to bedrock which outcrops on both hillsides but at the bottom of the valley dips to about 100 ft. below the surface. The rock is gneiss and the overburden is water-bearing sand and gravel. The present channel of the river crosses the site of the dam near the south end and the river bed is partly on the ledge rock which gradually dips away from the river to the deepest place near the middle of the valley. The method adopted for constructing the core-wall was to drive two walls of steel sheet piling across the valley, excavate between them, meanwhile bracing the steel sheeting with timber, and then fill the trench with concrete. The type of sheeting used was the Lackawanna, arch-web, 35 lb. section. Previous to putting down the sheeted trench, a stretch of open cut, with sloped sides, was taken out with a steam shovel, giving a level path upon which to erect

*Chief Engineer North Jersey District Water Supply Commission, Newark, N. J.

the frame for guiding the piling and for working the two pile-driving rigs, one on each side of the trench. These rigs had an A-frame 75 ft. high, with an extension to a total height of 92 ft., giving a clearance sufficient to handle and mesh one 50-ft. pile into another when the latter has been driven about 10 ft. Rigs were equipped with Warrington No. 1 steam hammers and mounted on skids sliding on sills laid normal to the trench.

*Pile-Driving Methods.* In driving the piling the method used was to put the sheeting down as a wall and not as a series of individual piles. First a portable guide frame 48 ft. long made of 12 x 12-in. timbers was set up over the deepest part of the trench. This frame was constructed so that it could be adjusted to various widths. The aim being to obtain

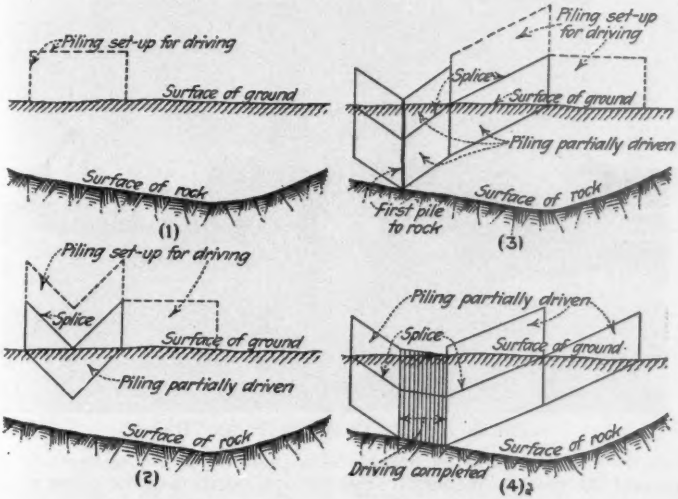



SECTION OF DAM AT MAXIMUM CORE-WALL DEPTH.

a trench 20 ft. wide at the bottom, and there being no experience upon which to determine the probable deviation of sheeting for such deep driving, the guide frame was first set to a width of 22 ft. After the piling was driven, the average top width was found to be actually 21.5 ft. The deviation from the vertical at the rock was found to be about 6 in. for each wall of piling, sometimes wider and sometimes narrower than the width at the top. On top of the rock the slope of the ledge surface forced the piling out of line so that the narrowest trench was 18.6 ft. and the widest was 24.4 ft. Later on with this experience to govern and for the shallower trench the width was reduced to 14 ft.

A wall of 50 ft. steel piling was set up on each side of the guide-frame and driven into the ground a few feet so as to hold the toe in place. Extreme care was exercised for the first set to have the piling true and plumb. This precaution was found to be very important as the first piles driven serve as pilots for all succeeding piles. Succeeding frames were also set

up very carefully. After the first stretch of piling was erected, driving was begun on a set of three piles at the middle of the frame. When the first three piles were driven a few feet the adjacent three on each side were driven, and so on, the rule being, in general, to drive no pile more than 4 ft. in advance of its neighbor. This method was continued until the top of the middle pile of the set was down to the surface of the ground, the bottoms of the adjoining piles then being in staggered diagonal lines to the surface of the ground. The frame was then moved ahead, another frame-full of piling set up adjoining the first, and driving resumed until the new set



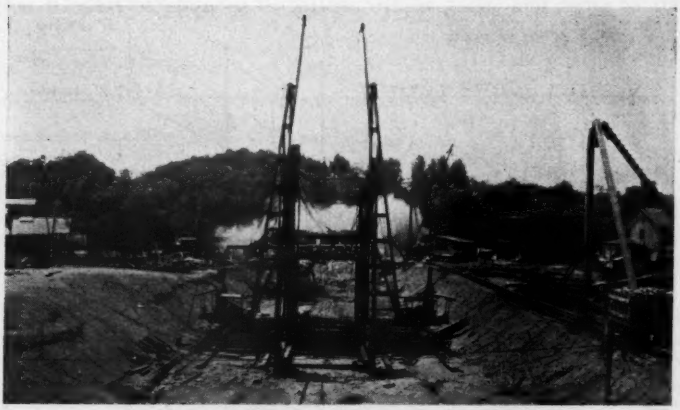

SEQUENCE OF OPERATION DRIVING SHEET PILING.

and adjoining members of the first set were down to the surface of the ground, the end piles being always left stepped-up in approximately 4 ft. steps.

As required, additional lengths of piling were spliced on top of the lower set by means of a 7-in. channel and a $\frac{3}{8}$-in. x $6\frac{1}{2}$-in. plate, bolt-holes to fit being previously punched in the ends of the piles. In this manner, by gradually working the wall down with its bottom to a slanting line, one of the steel members finally intersected the line of rising rock as shown more clearly on the diagram. While the first frame was set up over the deepest point, the first pile to strike rock was some 50 ft. to the south. Driving to rock continued then until the rock outcrop at the north end of the dam was reached.

The lengths of piles to be driven were at first determined by scale from the rock profile developed by the original borings, but on account of the great unevenness of the rock it was later found to be better to make

careful soundings, with the pile-driving rig and a steel rail, on the line of piling to determine the appropriate lengths of piles more accurately in advance. After the sheeting had been extended to the north end, the pile-driving rigs were moved to the other end of the walls of piling, the frame was set up and the same methods used to extend the sheeting to the south end of the dam. When possible, sets of three piles were driven at one time but when the penetration became difficult two piles were driven and finally for the deepest part only one pile was driven at a time. The maximum length of penetration was 84 ft. and the slowest driving in that vicinity



SHEET PILING RIG, GUIDE FRAME AND DERRICK.

was some 90 blows to the inch. The vertical position of the piling as established by the first set driven was maintained throughout the job so that no special wedge shaped pieces were required.

A typical gang consisted of 1 foreman, 1 pile-driver operator and 6 pile-driver men for each rig. Two rigs were run under one general foreman and high pressure steam was supplied from a central plant so that a fireman was not usually employed with the driving rig. Pile-driving progress for two rigs is shown in Table 1.

TABLE 1. — PROGRESS OF DRIVING OF STEEL SHEET-PILING.

| Month. | Sq. Ft. | Month. | Sq. Ft. |
|---|---|---|---|
| April, 1921 | 5 600 | November | 900 |
| May | 6 500 | December | 200 |
| June | 9 200 | January, 1922 | 100 |
| July | 14,700 | February | 15 800 |
| August | 5 200 | March | 6 000 |
| September | 6 600 | April | 9 900 |
| October | 12 800 | May | 6 400 |
| | | Total | 99 900 |

*Excavation.* As soon as the driving was completed at the north end excavation was begun with clamshell buckets operated from stiff-leg derricks running on a track on top of the west bank. As fast as the trench was excavated the sheeting was supported with 12-in. x 12-in. braces in bays 10 ft. on centers with the wales and braces spaced 6 ft. apart vertically for the upper 32 ft. of the trench. Below this the spacing was reduced

TIMBERING OF DEEP-CORE WALL TRENCH.

to 3 ft. vertically and subsequently altered to double sets 6 ft. apart. Rangers 14 in. x 14 in. and 12 in. x 14 in. braces were used for the lower portion of the trench. Pumping was required immediately after the installation of the top set of bracing. Two 8 in. discharge, Morris Machine Co., 60 in. diameter, centrifugal dredge pumps were installed and dredged a considerable yardage of sand and gravel out of the trench, depositing it on the downstream dam embankment, besides pumping water. In addition the following pumping equipment was used: Four No. 9 Pulsometers; two 5 in. Emersons; Two Lawrence 5 in. electric centrifugals and one Worthington electric 100 h.p. 6 in. discharge, centrifugal. The quantities of water pumped are given in Table 2.

TABLE 2. — MONTHLY OUTPUT OF TRENCH PUMPS IN MILLIONS OF GALLONS.

| | | | |
|---|---|---|---|
| March, 1921 | .6 | December | 90.5 |
| April | 1.9 | January, 1922 | 81.0 |
| May | .2 | February | 70.5 |
| June | 3.2 | March | 120.3 |
| July | 41.5 | April | 115.8 |
| August | 138.9 | May | 116.6 |
| September | 102.4 | June | 114.4 |
| October | 101.2 | July | 94.2 |
| November | 85.8 | August | 19.2 |

Rates of 5 000 and 6 000 g.p.m. were pumped in February, 1922, when the longest stretch of deep trench was open. The total pumpage was about 93 000 million foot-gallons.

BOTTOM OF DEEP CORE-WALL TRENCH.

BOTTOM OF DEEP CORE-WALL TRENCH.
Good Contact between Steel Piling and Rock.

Due to the porosity of the material and the low rainfall, the ground water level was very considerably lowered during the fall and winter of 1921-22. In general it remained about 20 ft. above water level in the trench. The result of this was to appreciably reduce the pressure on the timber tracing. After a few timber sets had been put in and the trench excavated about 40 ft. deep the bracing began to show strain; one wale

cracked longitudinally in about the middle, some of the bracing cut into the wales as much as ½ in. and some of the braces split at the ends. A closer vertical spacing was considered, but the only change actually made was to substitute oak for pine bearing plates at the ends of the braces and to frame the timber with even greater care than before so as to be sure of a bearing over the entire 144 sq. in. section.

As the trench was deepened the ground water dropped and the pressures apparently never again reached those which obtained in the more

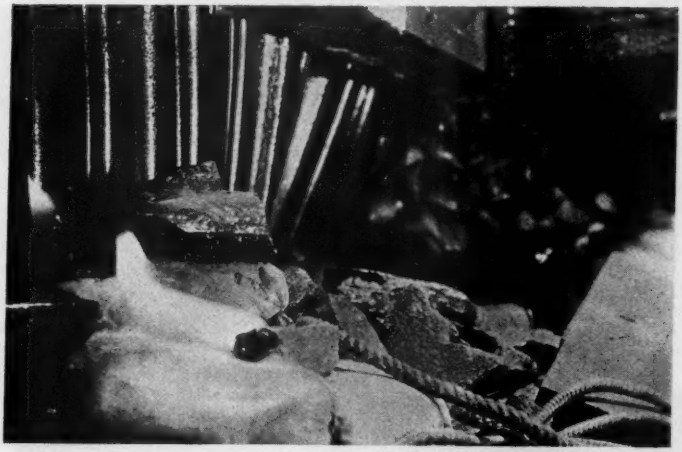
BOTTOM OF DEEP CORE-WALL TRENCH.
Good Contact Between Steel Sheet Piling and Rock.

shallow trench. Most of the braces when removed were sawed and cut out with no great difficulty and some were pulled out with a cable from a derrick hoisting engine without any cutting. In general, the contact of the steel piling with the rock surface was found to be most satisfactory but in a very few places the piling had encountered rock fragments near the bottom and had been twisted out of its interlock. There were a few piles that had been overdriven and "fishhooked." A small pile hammer was rigged on a derrick set upon the berm of the sloped excavation and any piles not showing a tight contact were redriven as was found necessary.

Turned up piles were burned off. For a stretch of about 20 ft. on one side in the bottom of the deepest section of the trench an additional set of short piling was driven inside of the original set. This was the only place where a double set was required.

*Method of Concreting Core-Wall.* As soon as the earth was excavated from the northerly end of the trench, the concreting of the core-wall was begun. Aggregate was obtained from a gravel bank on the opposite side of the river located on a terrace about 35 ft. above river level about one-

half mile away from the core-wall. The material was excavated by means of a steam shovel, hauled to and run through a crusher and a revolving screen. The portion of the output of the screening plant which could be used at once was hauled directly to the concrete mixer and the remainder stored in the excavated part of the pit for future use. There was about 50 per cent. of excess sand in the pit which had to be wasted. The concrete mixing plant located 300 ft. from the core-wall trench consisted of aggregate storage piles feeding into bins by a derrick and two Ransome,



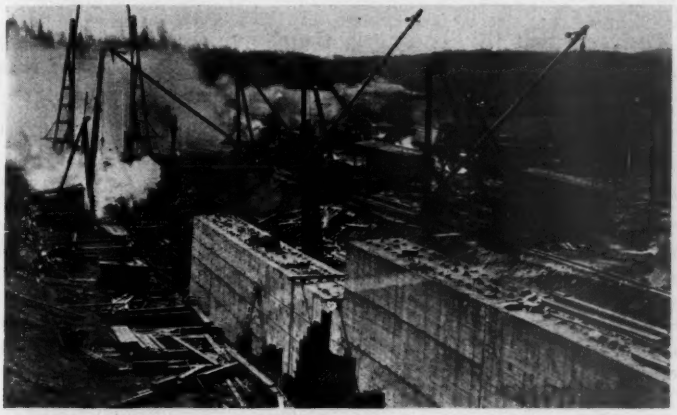
BOTTOM OF DEEP CORE-WALL TRENCH.
Bad Contact Between Steel Sheet Piling and Rock.

size 53, mixers. Mixed concrete mostly proportioned 1:2½:5 was deposited in bottom-dump buckets hauled to the core-wall trench on narrow-gage flat cars and transferred by stiff-leg derricks to the concrete forms. In the bottom of the trench, on account of the interference of timbering, concrete was placed through hoppers feeding into a vertical 10-in. steel pipe.

In the first part of the work the water in the bottom was handled with no difficulty by means of blind drains or pipes on the sides of the trench next to the sheeting, but as the deeper portion of the trench was reached the quantity of water increased and begun to interfere with placing the concrete. The ground water back of the sheeting began to leak through and flow onto the concrete up to a level some 20 ft. above the bottom of the trench.

To obviate this trouble holes were burned in the sheeting near the bottom and 2 in. pointed and perforated pipes, 3 or 4 ft. long, were driven into the earth back of the sheeting. These drained the water away from the back of the piling so that the flow into the trench was largely confined

to these bleeder pipes and was easily controlled. The bleeders were also useful in holding the ground water level down so that there was no difficulty in placing the subsequent layers of concrete. For the concrete in the deepest section additional precautions were used. The concrete was placed in short stretches, 10 or 20 ft. long, and first a concrete bulkhead about 6 in. wide and 2 ft. high was built on either side about 2 ft. from the sheeting. Back of this wall a blind drain or pipe, sometimes connected with the bleeder pipes, carried the water ahead. Between these bulkheads



UPPER PART OF CORE-WALL UNDER CONSTRUCTION.

concrete could be placed in the dry and afterwards the space back of the bulkheads was concreted, blind drains and drain pipes being cut off periodically.

Concreting was carried on from the north end of the trench towards the middle until the deepest point in the excavation was reached, Sta. 5+00, where the principal pumping plant was located. Operations were then undertaken part way across the valley near Sta. 7+50, at a point where there was a natural sump in the rock. Here another pump was installed and operations by the same methods as used before continued in the opposite direction until the gap between the new pump and the main pumping plant was filled. Then the closure at the deep place was undertaken, the space between the finished sections of core-wall being about 40 ft. Parapet walls 6-in. wide were built longitudinally across this stretch about 2 ft. inside of the sheeting; and the water which came underneath the piling or through bleeder pipes was concentrated on either side between the parapet and the steel piling, leaving the center clear and dry to be filled with concrete. When the center wall had been carried up about 6 ft., the spaces between the parapets and the steel piling were filled with rock fragments and the top was sealed over with concrete from one wall of steel piling to

the other, leaving vertical steel pipes built into the concrete for pump suctions and float wells. The pumps were then arranged in three sets, one having its suction on the upstream side, the second on the downstream side and the third was arranged so that it could be switched to either side when one set of pumps of the three was being raised. By this means, alternately raising one pump at a time and concreting under it and building the suction pipes up, the closure in the deep section was accomplished. Meanwhile concreting proceeded at the river end of the trench where the rock is not so deep and was completed in that stretch before the final closure was made.

To insure that the concrete in the closure section might never be flooded the pump sections were built up clear to the top of the sheeted trench and pumping continued until the last batch of concrete below ground water level was placed.

TABLE 3.— MONTHLY PROGRESS OF CONCRETE IN CORE-WALL.

| | Cu. Yds. | | Cu. Yds. |
|---|---|---|---|
| September, 1921 | 94 | March | 1 484 |
| October | 932 | April | 1 750 |
| November | 1 307 | May | 6 095 |
| December | 315 | June | 5 377 |
| January | 1 621 | July | 5 862 |
| February | 2 061 | August | 8 502 |
| | | TOTAL | 35 400 |

The refill of the sloped excavation on the upstream side with rolled impervious material and on the downstream side with sand and gravel placed by the hydraulic method — both direct pumping and slushing from a dry fill — is in progress.

The construction of the core-wall was under the direct supervision of N. C. Holdredge, Assistant Chief Engineer, the contractor was W. H. Gahagan, Inc. and subcontractor for driving the piling was J. Roy Horton.

## DISCUSSION.

MR. ROBERT SPURR WESTON.* What was done with the piling after the core-wall was put in?

MR. PRATT. We pulled some of the piling in the north end to use a second time to close up the end in the river. I did not go into the detail of saying that in building this wall to the river there was a short stretch which was left to be finally closed after the deep trench was filled. The rest of the piling was cut off at the surface of the ground and left in place.

* Consulting Engineer, Boston, Mass.

# TOPICAL DISCUSSIONS.

## THE FLUSHOMETER.

*[September 15, 1922]*

MR. FRANK. A. MCINNES.* I should like to ask our members what experience they have had, if any, with flushometer closets. With the advent of modern plumbing requests are coming along for 4 in. pipes where we have been granting 3 in.; for 3-in. pipes where we have been granting 2 in.; and for 2 in. where we have been granting 1 in., and I now have one case in the new Chamber of Commerce Building where a modest request is made for a 6 in. This is all caused by the demands of the flushometers.

We have not had sufficient experience to know what the flushometer requires for proper service, nor can any of the plumbers I have talked with give the information. They simply claim they must have the water.

From the present outlook, the flushometer, operated without a tank directly from the pressure, may easily become a serious matter, perhaps in time rivalling our friend the fire pipe.

MR. CARLETON E. DAVIS.† What pressure do you have to have for the flushometer?

MR. MCINNES. I can only answer by saying that all of our pressures appear to be satisfactory; from 45 to 90 lb.

MR. DAVIS. Is there a limited pressure?

MR. MCINNES. I do not know.

MR. DAVID A. HEFFERNAN.‡ Mr. Gordon M. Fair, Instructor in Sanitary Engineering, Harvard Engineering School, read a paper before this Association on February 9, 1921 on the Flush Valve. This paper was published in the JOURNAL, June, 1921, and contains much valuable data.

In large cities where flushing valves are used in modern buildings, facilities must be adopted by the storage of water in tanks, or to make independent corrections by direct pressure to the valves. This latter method requires larger services and is objectionable to the water departments.

In my opinion the use of these valves by direct pressure should be discouraged as much as possible by water-works officials.

PROF. GEORGE C. WHIPPLE.§ The Plumbing Committee of the department of Commerce working in Washington the last year studied

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*Division Engineer Public Works Dept., Division of Water, Boston, Mass.
† Chief Bureau of Water, Philadelphia, Pa.
‡ Superintendent Water Works, Milton, Mass.
§ Professor of Sanitary Engineering, Harvard Engineering School.

that very carefully at the Bureau of Standards. We have not as yet tested the flushometer, but have tested the ordinary closets. Experiments have given us the rate of flow each second the time the chain is pulled until the flush goes out. I think when we get through with our work we will know just what is needed for rate of flow, both for the flushometer and the other kinds. At the present time, with the ordinary closet, you will find the maximum rate of discharge is about a gallon a second. It runs up to that and then drops off.

MR. MCINNES. There is the whole point. It is the maximum demand for the flush closet that we are looking for.

PROF. WHIPPLE. We will probably have that part of the work done within three or four months.

MR. MCINNES. You are probably aware of the great demand for flushometer closets. It is coming up in every new building.

PROF. WHIPPLE. People are asking for it for small houses, too, which is the worst feature of it all. I do not think the plumbers really like the flushometer, it is the architects, rather than the plumbers themselves.

MR. MCINNES. It is something we have got to meet.

MR. W. C. HAWLEY.* I have had some experience with the flushometer proposition. Occasionally, in the case of a private house, the demand is made for a service line from twice to five times the size which would be necessary for an adequate supply for the house if it were not for the flushometer. There is not only the question of the increased investment in service line and meter, without any corresponding increase in the amount of water sold, but in the case of a water works carrying a high pressure on its mains, there is the added danger of "water hammer." I have taken the position that while we were willing to furnish all the water that was wanted, we would not undertake to furnish ninety-nine per cent. of the water in one per cent. of the time, and that if they wanted service of that kind, some arrangement for storage should be provided. We had one case where there were 20 flushometers installed in a school house, with a demand for a 4 in. service line, or at the very least a 2 in. service line. At our suggestion, however, they installed a surge tank in which water is stored with air under pressure, and a 1 in. service line has given satisfactory service for several years past.

PROF. WHIPPLE. There is one other phase of that problem. We find that a very large part of the difficulty of designing plumbing systems has to do with the coincident discharge of the fixtures. That is a thing about which we are absolutely ignorant. If a half dozen flushometers are going off at absolutely the same instant, then there must be a big supply, but if one discharges after another, if they take turns, then it is not necessary to provide for as large a supply. The thing we need to look into is the question of coincident discharge. How much of a factor of safety must

* Chief Engineer Pennsylvania Water Co.

be provided on account of the different fixtures going off at once? There is where the crux of the problem lies.

MR. MCINNES. Absolutely.

MR. F. N. CONNET.* Some years ago I saw a water closet in which a large air chamber was used in connection with the flushometer, and that made a storage of about a cubic foot of water at the point where it was needed, so that the compressed air aided in flushing the closet without a very large, sudden draft on the main pipe. I thought the idea was good, but it does not seem to have been followed out.

MR. M. N. BAKER.† It is interesting to hear that at this seemingly late day the flushometer is coming rapidly into use. I well remember writing an illustrated description of the device when it was brought out twenty-five years ago (*Engineering News*, 1897-II, P. 260). Quite recently I was wondering why I did not see or hear of the flushometer more frequently. It is interesting to know that all of a sudden something seems to have happened. Somebody must be getting behind the device, pushing it hard, either the manufacturers, or else the architects have become suddenly convinced. It would be interesting to have some light thrown on the recent movement to indicate whether it is likely to die down or go on and become a big problem for water-works men.

MR. DAVIS. Does it really flush any better than the old time tank? Is it any more sanitary? Isn't it merely an indication of the tendency of modern extravagance?

PROF. WHIPPLE. It looks neater and avoids the unsightly tank. It is a matter of luxury.

MR. FRANK A. MARSTON.‡ I would like to suggest that if this matter is going to be studied it would be worth while to measure the rate of discharge from mills such as are in New Bedford, and big schoolhouses, where many flushes are to be expected almost simultaneously, as for instance, during the first few minutes after closing time in a large mill, or at recess time in a school. In an office building, the conditions are entirely different. But little information is available on this subject, and it would be helpful if something could be done to accumulate such data.

PROF. WHIPPLE. We have not taken any steps to find that rate. It would be necessary to use meter records.

PRESIDENT BARBOUR. If you had some kind of record of discharge in large buildings from minute to minute right through the day you would get some information.

PROF. WHIPPLE. It would be a simple matter to keep a stop watch and find out how frequently the discharge came. That has been done in the Grand Central Station in New York for a half hour and record kept of the number of times they heard the discharge go out, and it is surprising

* Builders Iron Foundry.
† Associate Editor *Engineering News Record*.
‡ Of Metcalf & Eddy, Boston, Mass.

how infrequently there are simultaneous discharges. I think we have been allowing for too big a factor of safety.

MR. WILLIAM W. BRUSH.* I have not had any personal experience with this, Mr. President. So far they have not affected materially the supply, except the question of the size of connections. We have two pressures in the upper part of Manhattan on account of flushometers. When the Catskill system came into it, it was planned to place the greater part of northern Manhattan, which has previously been tower service, on the Catskill service, with a gradient at that point of around 285. That gave a pressure of between 40 lb. and 50 lb. in that section which was previously 60 lb. or more. Complaints came in from the large new apartment houses in that section, because they were using flushometers, and with the 40 lb. pressure at street level — they were about six story apartments — they did not get satisfactory flowage for the flushometers, so that we changed over quite a large area and put it back on the tower so as to get satisfactory service.

## PAINTING FIRE HYDRANTS

[*September 15, 1922.*]

MR. CARLETON E. DAVIS.* In Philadelphia we paint our fire hydrants yellow. Red paint on fire hydrants is seen all right in the daytime, but you can't see them at night. The same thing holds true with green. The aluminum tops are too expensive; it takes too long to put them on. Finally we tried yellow paint, and it appears to be a very satisfactory color. The firemen like it, and it stands out conspicuously. You can see yellow in the night time under light, you can see it in the day time, and on a foggy or misty day. Furthermore, yellow is a bright contrast in the streets. The electric light and telephone pole is generally a dark color, and with the fire hydrants painted yellow they stand out conspicuously. The traffic policemen tell me they like the yellow hydrants because there is no excuse for people parking their cars in front of the hydrant. Ordinarily with the fire hydrant a dark color they will pay no attention to it; but when you paint it yellow the traffic officers will say, "Can't you see this yellow fire hydrant?" We do not pick the very bright color, but take a shade called "4", which is something like an old fashioned New England pumpkin in its luscious and ripe state.

Incidentally, we are painting our pumps the same color in place of green, formerly used. Our largest pumps, which are 12 twenty million gal. pumps, are painted yellow with black trimmings, with the steam pipes painted yellow. It has a wonderful effect on the men and tends to keep them awake at night. It affects the eye, and has a good psychological

* Deputy Chief Engineer, Bureau of Water, New York.
† Chief of Bureau of Water, Philadelphia, Pa.

effect. Yellow reflects the light on the moving parts, so that they are more easily seen. It is rather a shock when you think of painting pumps yellow, but you will remember that in the old times yellow was the standard color for marine engines, and it was for a purpose, because it lightened up the dark parts of the engine. We have come back to yellow, and shall keep on with it. It is a first class hydrant color. The base of the hydrant we paint black, about 6 to 8 in. up from the ground.

MR. DAVID A. HEFFERNAN.* The only trouble with that color would be that you would have to go over your hydrant more often; it would be apt to get dirtier.

MR. DAVIS. Even if they do get dirtier, the yellow shows through the dirt. If you paint green or red or black, the dirt seems to obscure them even more than with yellow. The yellow is a penetrating color, and it seems to come through the dirt.

MR. HEFFERNAN. We paint ours black, and just use a bronze paint.

SECRETARY FRANK A. GIFFORD. How often do you paint them?

MR. HEFFERNAN. Every two years.

MR. DAVIS. We have not had as many collisions with the yellow hydrants as we had with the other colors. They are conspicuous to the automobilists.

*Superintendent of Water Works, Milton, Mass.

## FLORENCE M. GRISWOLD.

FLORENCE M. GRISWOLD was born in Hoboken, New Jersey in November, 1834. He received his education in the public schools and at Wittenburg College, Springfield, Ohio. During the Civil War he served with the Union forces, enlisting from Mainville, Ohio near Cincinnati. At the close of the Civil War he returned to Cincinnati and became Special Agent of the old North American Fire Insurance Company of New York, and under the supervision of his father, Jeremiah Griswold, General Agent of the Company spent several months in general field work in that territory. In 1866 he was appointed Assistant General Agent of the Company and served in that capacity until 1870. In the succeeding five years he was connected in various responsible capacities with several of the principal fire insurance companies, becoming in 1875 the General Inspector of The Home Insurance Company of New York with headquarters in New York City. Since that time he has had particular charge of the special hazards and technical work conducted by The Home Insurance Company throughout the whole field of its operations.

Mr. Griswold's father, Jeremiah Griswold, was himself a well known insurance man, having been associated with the Aetna. Jeremiah was the author of "Griswold's Handbook on Adjustments," "Griswold on Insurance," "Underwriters' Text-Book" and other authoritative publications on various phases of the insurance business.

At the time of his entry into fire insurance, the business was admitted to be a "System of magnificent guessing" as to hazards and rates, wherein a risk was assumed almost without regard to physical or other hazards. A short experience convinced Mr. Griswold that such method was entirely empirical and he began to study the needs of the situation in order to reach a basis having some evidence of scientific principles underlying it, and to put into operation the conclusions arrived at. Among the most important of these was the realization that the obligations existing between the insurer and the insured are properly mutual, and that anything which tends to the profit or safety of one is of like value to the other.

Building upon this foundation, he undertook to make himself familiar with the processes and methods of all classes of manufacturing industries and the fire hazards incident to each, and then began the work of making better that which came under his supervision. He assisted in the organization of many of the inspection bureaus, and had an active hand in the formulation of a number of schedules for rating industrial plants. From the length of his service and the knowledge gained by his unceasing study and investigation of fire hazards, he perhaps became one of the best versed men in his profession and was frequently referred to as "The Dean of Fire Insurance Engineers."

Following, naturally, in the line of preventing the occurrence of fires, arose the necessity for their extinguishment. In this line of investigation he devoted much attention to the betterment of public and private fire protection, and in pursuit of this particular line of knowledge and information, Mr. Griswold was brought into intimate contact with the fire and water departments of many of the principal cities of this country, and was known by them as an authority in this line. For many years he was an ardent advocate and a strenuous worker in an attempt to secure universal standards for all classes of fire-fighting facilities and utilities, especially for public fire hose connections. The need for standard hose and hydrant threads was apparent, and in view of the broad experience and wide acquaintance he had throughout the country, the National Fire Protection Association selected him to head a special committee to secure the adoption of a universal standard. Mr. Griswold accepted the task with full knowledge of the many attempts and failures of past efforts for its accomplishment. As the result of his persistent effort he secured the official endorsement of his coupling by all of the leading and most influential organizations of this country, thus establishing a standard coupling, the adoption of which has become general in all parts of the country, and in 1917 was approved and adopted by the United States Bureau of Standards as the "National Standard Hose Coupling and Hydrant Fitting" for public fire service.

Mr. Griswold was a member of the Grand Army of the Republic, the American and the New England Water Works Associations, The American Society of Mechanical Engineers, and associate member of the International Association of Fire Engineers, to which organization he has for many years been the accredited delegate from the National Fire Protection Association; and Honorary Foreign Correspondent of the British Fire Prevention Committee, and an Honorary Life Member of the National Fire Protection Association.

He was active in his line of work, kept in close touch with all technical matters affecting fire prevention work, and few men have had so important a part in bringing fire underwriting to a point where it can in some truth be called an applied science.

During his business connection, embracing forty-seven years in the study of the technical principles of fire underwriting, many authoritative publications on fire prevention were prepared for The Home Insurance Company, whose interests he held paramount to all others.

We can testify to his strict integrity and loyalty, and regret with all others who had the pleasure of his acquaintance, that so much has been lost to the fire insurance business. Morally, mentally and physically he was a high type of man, and he will be sorely missed by all.

# PROCEEDINGS.

The following is a synopsis of such parts of the proceedings at the New Bedford convention as appears to be of value for the record.

## FORTY-FIRST ANNUAL CONVENTION.

NEW BEDFORD, MASS.
September 12, 13, 14, 15, 1922.

The Forty-First Annual Convention of the New England Water Work Association was held at New Bedford, Mass., September 12, 13, 14 and 15, 1922.

The sessions of the convention were held on the top floor of the New Bedford Hotel, where also were provided accommodations for the exhibits of the Manufacturers.

The Convention was called to order at 10.30 A. M., September 12, by Stephen H. Taylor, Superintendent of the New Bedford Water Works.

MR. TAYLOR. Mr. President, ladies and members of the Association: It gives me great pleasure to introduce to you Hon. Walter H. B. Remington, Mayor of the City of New Bedford. (Applause.)

### ADDRESS OF WELCOME BY HON. W. H. B. REMINGTON, Mayor of New Bedford.

MR. REMINGTON. Mr. President, ladies and gentlemen of the Convention: During the past summer it has been my privilege to extend a word of welcome in behalf of the City to several Conventions, and it has been a pleasure to do so in each instance. It is no less a pleasure to extend New Bedford's hearty welcome to the representatives of the New England Water Works Association, and I do so with the best wish that your stay with us may be enjoyed. New Bedford has a particularly warm spot in its heart for the New England Water Works Association. For many years our Superintendent of Water Works, Robert C. P. Coggeshall, was prominently indentified with your Association in an official capacity, and by reason of his enthusiastic appreciation of the work which the organization was doing for the procuring of pure water we have come to know you well. Our system, which you will inspect before you return to your homes, is a monument, in a way, to Mr. Coggeshall's fealty to the ideals of the New England Water Works Association. We are proud of it, and we are proud of him and of the members of the Water Boards who have worked with him to achieve the results which we are able to show you.

You will learn, if you do not already know about it, that others appreciate our system as much as we do ourselves, and are anxious to share in what we have. We are not unwilling to share but we do have the same feeling that induced the ox in the fable to kick when somebody farther up the stream polluted his drinking place. We are satisfied to be let alone, and we cannot see any good reason why we should be disturbed in the possessive use of a water system which we have developed and protected at considerable expense.

But we cannot expect you to be interested in our affairs during your visit to New Bedford. Your Convention has affairs of its own, which will doubtless claim your attention. But we do expect you will have a good time while you are in New Bedford, and if there is anything lacking to that end just mention it to Steve Taylor — he will do the rest. (Applause.)

MR. TAYLOR. Mr. President, it is a pleasant priviledge to introduce Mr. William Ritchie, President of the Board of Commerce of New Bedford. (Applause.)

## ADDRESS OF WELCOME BY WILLIAM RITCHIE, President Board of Commerce.

MR. RITCHIE. Mr. President, ladies and members of the New England Water Works Association: The Board of Commerce represents the industrial, mercantile and civic activities of the City, and they welcome you for two reasons: First, we are always glad to see visitors; second, we are proud of New Bedford's achievement in the development of its water works, due to the foresight and sagacity of some of our citizens.

My predecessor as President of the Board of Commerce, Mr. Edmund Wood, was a member of the original commission which started this development. When those far-seeing business men started their work they were criticised by officials of other cities, and it was with a great deal of effort that they prevailed upon our wise legislators to permit New Bedford to finance the matter from time to time. The judgment and vision of those men have been demonstrated by our water system as developed to-day, as I think that you will agree with me after a visit to the works.

We are indeed glad to have this convention of experts meet in New Bedford and observe our system, and we hope they will endorse our opinion of the system. We hope also that they will observe at the same time the great industrial and civic growth of our city, which is also due to the type of men who were responsible for the development of our water system.

I heartily endorse all our Mayor has said. The Board of Commerce is made up of the leaders in our business and civic activities, and we have formed an organization for service, — service to the community, service to the individual, and service to visitors. I, in their behalf, welcome you,

and invite you to use that service in any of our numerous boards or divisions while you are here, one and all, and we trust that that service will be able to make your visit here both pleasant and profitable. And, as our Mayor has said, if we do not live up to it, go to Steve Taylor and ask him why. (Applause.)

### Response by President Frank A. Barbour.

The President. Mr. Mayor, Mr. Ritchie: For the Association I thank you for your words of welcome. That these words are to be translated into very tangible hospitality we have ample proof in the program of entertainment which has been prepared. As presiding officer my fear is that the attractions of your city will be so great that our technical sessions may suffer and the serious purpose of this convention be in some measure lost sight of, and we have a very serious purpose in these meetings.

We believe that there is no other public utility entrusted to municipal officers that compares in point of responsibility with the water system. It is possible for a city to live without gas or electricity, or good streets and, for a time, without sewers, but if for any reason the water supply is cut off for a very short period, municipal life is ended. We believe that it is only by associations such as this, that the men in charge of this most important public service can be kept up to the highest efficiency, and that attendance at these conventions is the most direct means of deriving from this Association the best that it has to offer.

I am glad to know that it is the practice in New Bedford to pay the expenses of the department officials to the meetings of this and other associations. In my opinion the well-known efficiency of your department is largely the result of the attendance of such men as Mr. Coggeshall and Mr. Taylor at these meetings, and I think it would be a very wise thing for all cities to follow the course that New Bedford has adopted.

It is thirty-six years since we last met here in New Bedford, but you will credit us with the fact that we came back just as soon as you had the necessary hotel accommodations. There are several reasons why we should meet in New Bedford. The growth of your city during the past twenty years has been one of the outstanding facts in Massachusetts, — and as municipal officers — we are interested in finding out how you have kept step with this growth in your public utilities, and particularly in your water system. There is another reason for our coming here, and that is the hope that Mr. Coggeshall will feel that we are expressing in some measure by our coming the affection and respect that we hold for him.

We note that in the thirty-six years since we were last here — during which time you have grown from a population of somewhat less than forty thousand to somewhat more than one hundred and twenty thousand, you have had one man for Mayor twenty-two years, and I believe that same man has also been chairman of the Water Board. We expect to come

back again, Mr. Mayor, in about twenty years, or perhaps a little less, and I hope that we shall then find you in the same position you occupy to-day.

I again thank you, gentlemen, for coming here and welcoming us to your city, and we hope that it will not be necessary during our stay for us to refer the Police Department to our cordial relations with you.

On motion of Frederic I. Winslow, duly seconded, it was voted that the President shall at some time during the convention appoint a committee of five to bring in at the November meeting a list of nominations for officers for the ensuing year. The President later announced the appointment on this committee of Messrs. Charles W. Sherman, Samuel B. Killam, Frank Emerson, Richard H. Ellis and Thomas E. Lally.

On a motion by Mr. J. M. Diven, duly seconded and amended by Mr. George A. King, to omit the word " alternating " and have it refer to all currents, it was voted to appoint a committee to investigate the grounding of alternating currents on house plumbing, to act in connection with a similar committee of the American Water Works Association.

The following were duly elected members of the Association.

*Active*: John Brown, Resident Engineer, Fall River, Mass.; Julius W. Bugbee, Superintendent and Chemist, Sewage Disposal Works, Providence, R. I.; Steve C. Burghardt, Manager Water Company, Stockbridge, Mass.; John E. Gleason, Superintendent Water Department, Providence, R. I.; W. S. Lea, Consulting Engineer, Montreal, P. Q.; Alexander H. McDonald, Superintendent Water Department, Littleton, N H.; Joseph W. Money, Superintendent Warwick Water Company, Anthony, R. I.; Chester A. Moore, Consulting Engineer, Somerville, Mass.; Humphrey Sullivan, Foreman Hartford Water Works, Hartford, Conn.; Ellsworth B. Tolman, Assisting Superintendent Water Works, New Bedford, Mass.; John W. Mulcahy, Superintendent Water Works, Braintree, Mass.; Francis H. Nolan, Superintendent Water Works, Avon, Mass.; Richard F. Forrest, Superintendent Water Works, Randolph and Holbrook, Mass.; Edmund Dunn, Mechanical Engineer for Water Commission, Garfield, N. J.; Henry S. Charron, Superintendent Water Works, Burlington, Vt.; Ernest E. Lothrop, Town Manager, Mansfield, Mass.; A. A. Gathemann, Civil Engineer, Hanover, Mass.; Gilbert H. Pratt, Chemist, Belleville, N. J.

*Associates:* George A. Caldwell & Co., Boston 24; New England Oil Refining Co., Fall River, Mass.; Red Hed Manufacturing Co., 287 Atlantic Avenue, Boston 3, Mass.

## Report of Progress of Committee on Standard Specifications for Water Meters.

Mr. Charles W. Sherman. Mr. President, if it is not imposing on the meeting I should like to take a minute to make verbal report of progress for a committee. I am reporting for the Joint Committee on Specifications for Standard Water Meters of this Association and the American Water Works Association. The Chairman on the part of this Association, Mr. Brush, is somewhere around the convention, but I do not think he is here at the moment, and I would therefore report as Chairman of the Joint Committee.

The Convention a year ago accepted the standard specifications which were recommended for disc meters and continued the committee to consider other classes of meters. Good progress is being made and we expect to submit our report in print in the near future, so that it may be considered at one of the winter meetings of this Association and at the next annual convention of the American Association.

On motion of Mr. George A. King, duly seconded, it was voted, That the President be authorized to appoint a committee of Massachusetts members to consider the advisability of united action with the State authorities of Massachusetts on the subject of merging water departments with other departments in management and finance, or either of them.

## Award of Dexter Brackett Medal.

Mr. Robert S. Weston. The Committee on the award of the Dexter Brackett Medal, consisting of Messrs. Tighe, Taylor and myself, after having read all the papers presented in last year's Journal, have come to the unanimous conclusion that the paper which merited the medal was one written by the last speaker, Mr. X. H. Goodnough, Chief Engineer of the Massachusetts Department of Health. The paper was on the subject of "Rainfall in New England." That paper, as you know, was not only a presentation of the facts in an interesting way, but it represented twenty years' work, all under his guidance, and initiated by him.

(To Mr. Goodnough.)

I have great pleasure, sir, in presenting this beautiful medal, and I think you will appreciate it more, because you have been so closely identified with the work with which the founder had so much to do. (Applause.)

Mr. Goodnough. I need hardly say that I feel greatly honored at being the recipient of this medal. I knew Mr. Brackett, of course, very well. I was more or less associated with him for a great many years, and especially with Mr. Stearns, who I think was instrumental in getting up

this memorial. I connot conceive of a more satisfactory memorial to Mr. Brackett, who was one of the chief workers for this Association through all of its earlier years.

The work of the Association has really, it seems to me, been a wonderful one. I think that more than any other one thing, the work of this Association has aided in securing the very satisfactory water supplies which we now have practically throughout New England. When Mr. Brackett was first a member of the Association, some thirty years or more ago, we were still using water directly from the Merrimack River and other polluted streams, without any idea that that might be the cause of the typhoid fever which prevailed so extensively in those places. It was to members of this Association that we owed the discovery of a great many of the causes of sickness from water and the means of preventing it; also the practical means of providing a water which is safe and of excellent quality, which we have now generally throughout New England.

I greatly appreciate the honor which you have done me. (Applause.)

## Financing of Municipal Water Works.

President Barbour. It is almost impossible under the general laws to finance any improvement of water supplies with bonds running for reasonable terms. The result is that at the present time it is necessary to wait until the Legislature meets and obtain special legislation. Mr. Waddell, the Director of Accounts, has said to me that he would like to have the coöperation of this Association in going before the Legislature and getting some amendments in general legislation. I think perhaps it would be well if Mr. Sherman would state in a few words just what the present condition of the general laws is with regard to municipal finance pertaining to water-works improvements.

Mr. Charles W. Sherman. This is a matter really of considerable importance to us, — in Massachusetts at least.

The present law relating to the financing of municipal water works in Massachusetts is contained in two brief paragraphs of Chapter 719 of the Acts of 1913, and is as follows:

Section 6. Cities and towns, may incur debt outside the limit of indebtedness prescribed in this act for the following purposes and payable within the periods hereinafter specified:—

(2.) For establishing or purchasing a system for supplying the inhabitants of a city or town with water, or for the purchase of land for the protection of a water system, or for acquiring water rights, thirty years.

(3.) For the extension of water mains and for water departmental equipment, five years.

That is the whole thing, and you will see by this that, outside of a whole new system, five years is the limit of time for which bonds may be issued

for the installation of extensions of the system, or the buying of land for the protection of the supply. That is limited to five years unless you get special legislation. It means that the bonds must be paid within the five years, and in five annual payments. That was promulgated in 1913 and is about the worst ever. The provision is for serial payments.

This struck some of us as so raw that at one time Mr. William S. Johnson, Mr. Symonds and myself presented some discussion of the law to this Association, and followed it up by petitioning the Legislature as individuals for an amendment to the law.

Perhaps I might say that a further point in relation to the serial payment of the bonds requires that the payments shall begin at once and shall be for the whole amount, and that the payment in no year shall be less than that of a succeeding year. You have to pay as much in the first year as you do in any later year, if not more. If the sum is not equally divisible the larger amounts must be paid the earlier years. We presented what we thought was an unanswerable argument, but the best we could get out of the Legislature was that in the construction of new works the first payment might be deferred for a term of three years; thereafter there must be 27 installments to make it up. That does give you a little time to begin to get some money in before you begin to pay it out. Under the original law you must make as large a payment in the first year as in any other.

When we presented that discussion in the Association we got Mr. Waddell, who was then Clerk in the Board of Statistics, to come up and discuss our paper. He could not see our point of view, and he opposed what we wanted in the Legislature. It is therefore a great pleasure to me that he has now come around to see some light in the matter and recognized the interest of this Association in it, and asked the help of the Association to revise the law in some way which will presumably be more satisfactory to water works men and will be more satisfactory to him also.

With that in view I offer the following motion:

*Moved* that the President be authorized to appoint a committee of three members to confer with Massachusetts officials upon the desirability of a modification of the laws relating to the financing of municipal water-works, and to report their conclusions and recommendations to the Association.

MR. CALEB M. SAVILLE. That would have to be Massachusetts members.

MR. SHERMAN. I did not put it in the motion, but I assume that it would be Massachusetts members. It might be put in the motion.

MR. X. H. GOODNOUGH. I had hoped something of this sort would be done. The handling of the business has been somewhat elastic, to say the least, by a department which knows nothing whatever, or did know nothing whatever of the water-works business. I think a campaign of

education is sadly needed, and that some judgment should be used in regulating the issue of bonds without trying to bring everything down to a fixed rule. I hope the motion will prevail.

[The motion was duly seconded and carried.]

On motion of Frank A. Marston, duly seconded, it was voted that the thanks of the New England Water Works Association are hereby extended to Hon. W. H. B. Remington, Mayor of New Bedford; to the New Bedford Water Board, and to the other officials and employees of the City; to the members of the Honorary Reception Committee, the Local Committee of Arrangements, the Ladies' Committee, and to all others who have given so generously of their time and means to make this one of the most successful conventions in the history of the Association.

On motion of Mr. J. M. Diven, duly seconded, it was voted: *Resolved*, that the New England Water Works Association, in Annual Convention assembled, hereby extends to Robert C. P. Coggeshall, one of its founders, for many years its secretary and its past president, its sincere sympathy in his illness, and expresses its great regret that it has not been possible for him to be present at its meeting; and renews its expression of esteem and affection, and of appreciation of his great service to the Association.

On motion of Frank J. Gifford, duly seconded, it was voted that the thanks of the New England Water Works Association are hereby extended to the Water Works Manufacturers Association, and to the members of its committees, who have contributed so much to the success of this, the forty-first annual convention.

(*Adjourned.*)